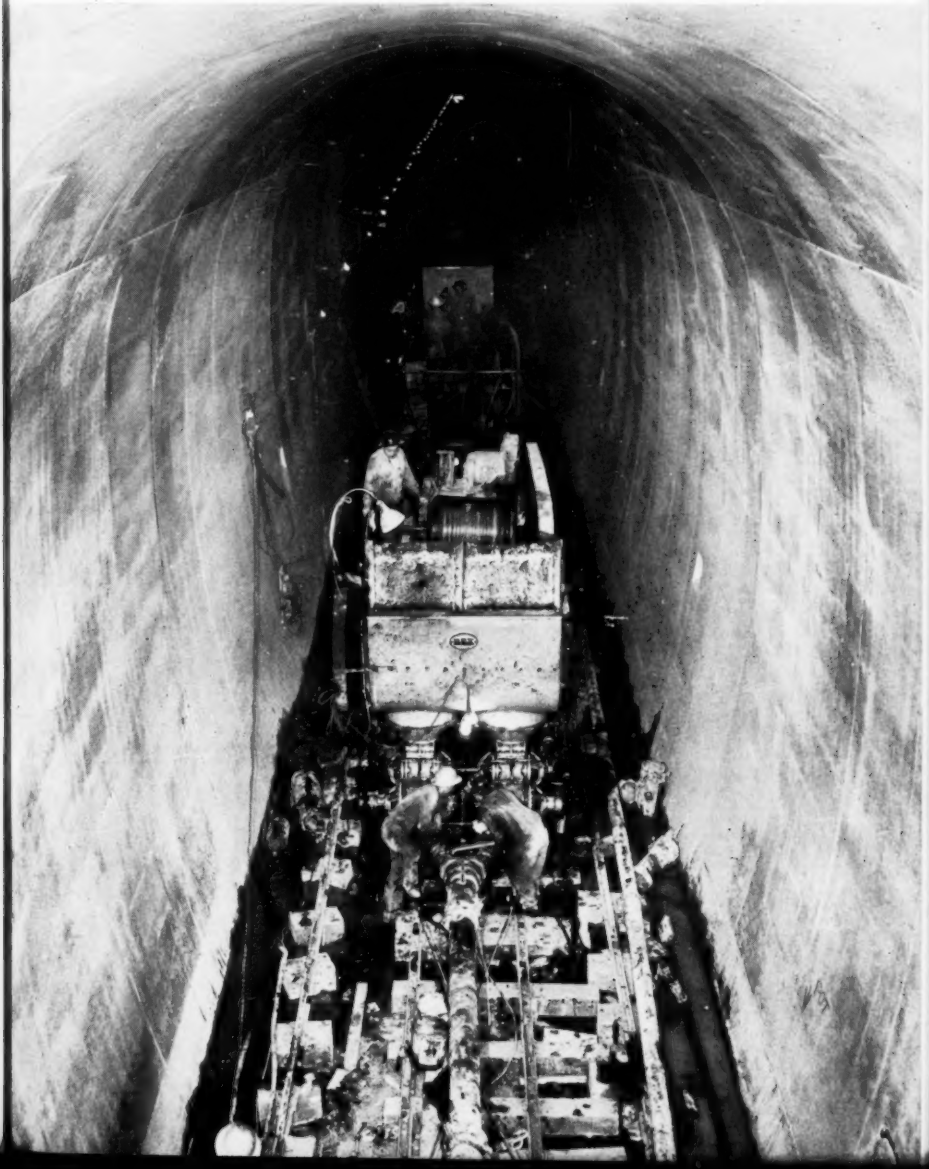
ACI News Letter

Vol. 21 No. 1 JOURNAL of the AMERICAN CONCRETE INSTITUTE September 1949



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Prepakt is made by first placing coarse aggregate in the forms; this is followed by filling the voids in the aggregate mass with Intrusion mortar. The resulting concrete possesses the following properties:

- Any desired ultimate strength—1500 to 7000 p.s.i.
- No setting shrinkage.
- 20 to 60% less temperature rise (due to heat of hydration) than conventional concrete.
- 50% less drying shrinkage.
- Superior weather resistance, especially to cyclic freezing and thawing.
- Superior resistance to action of salt water.
- High impermeability.

Prepakt, with all of these favorable properties, requires 30 to 60% less portland cement than ordinary concrete of equal strength. Prepakt may be made under water, as well as in the dry, with equal facility, and without increase in cement content. By placing forms and aggregate in winter months, seasonal shutdowns are not necessary.

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ACI

News Letter Contents

September 1949

On the Cover—After two years of drilling, blasting and mucking, concrete operations are under way in the boring of the new 6700 ft Aspen tunnel for Union Pacific Railroad in western Wyoming. Chuting pipe, Pumpcrete and mixer are in the foreground; all are track mounted. The electric lights along the tunnel's left wall lead to a tiny white spot more than 3000 ft distant, which marks the tunnel's east entrance.

Courtesy U. P. Railroad

Start Made in Construction of New ACI Headquarters..... 3

New England Regional Meeting takes shape.... 4

We Want to Know..... 5

Who's Who

- Committee 616..... 6
- J. R. Leslie and W. J. Cheesman 6
- I. T. Koudriashoff..... 6
- Ernst Gruenwald..... 6
- J. J. Waddell..... 8

Frank H. Powell..... 8

Charles E. Fontaine..... 8

Francis R. MacLeay..... 8

New Members.....10

Positions and Projects—ACI Members.....16

Honor Roll.....29

Tools, Materials, Services..32

Synopses.....33

List of Advertisers.....34

Discussion.....34

Start Made in Construction of New ACI Headquarters

Construction recently got under way on a new, modest but more spacious office for ACI headquarters. After 24 years in the Uptown region of Detroit—18 of them in the New Center Building—the Institute expects to occupy its new leased home farther out, about December 1 next.

ACI signed the first lease for space in the 10-story New Center Building in 1931. We have moved within that building several times with the ebb and flow of Members and of staff. But the office space available "Uptown" has not kept pace with ACI growth nor space demands in general. Staff efficiency has suffered by the proximity of elbows. The present location in general is good and has some advantages of services which will not be so close at hand in the new location. The modest one-story concrete masonry structure, whose walls are beginning to rise in the expanding northwest area, is at McNichols (longer known as Six Mile) Road and Rosemont—two blocks west of Southfield. McNichols (east to west) and Southfield (north to south) are major thoroughfares in an increasingly expanding and filling-in professional and business community—drawing new strength from the older congested downtown and uptown areas.

ACI's membership has more than doubled in four years. In a new home before the year's end, the staff confidently expects, with its "feet on the ground"—almost if not quite literally—and with a revised conception of a fuller service to diversified member interests, a new and greater growth of that membership.

New England Regional Meeting takes shape

The Committee for the New England Regional Meeting under the direction of Co-chairmen Henry L. Kennedy and Paul W. Norton is going full tilt on arrangements for a two-day program in Boston November 10 and 11, 1949.

Opening with registration at 9:00 a.m. Wednesday, November 10, at the Hotel Kenmore the first general session will convene at 11:00 a.m. with greetings from the City, State and Technical Schools followed by a talk of general interest relating to concrete.

At 12:30 p.m. an informal luncheon is planned to which engineering students will be invited. Officers and Directors of the Institute will be introduced and ACI President Gilkey will speak informally about ACI and its activities.

Wednesday afternoon will be devoted to a technical session of four papers and related discussion on concrete.

A tea for the ladies is tentatively planned for Wednesday afternoon.

At 7:00 p.m. Wednesday a dinner meeting with a speaker on a nontechnical subject of general interest is proposed.

Friday morning, November 11 will be devoted to a technical meeting of four papers and discussion. A ten minute interval from 10:55 to 11:05 is being set aside for Armistice Day observance.

Inspection trips scheduled to fill the interests of members and visitors are scheduled for the afternoon.

Members in New England, New York and the eastern provinces of Canada are particularly invited to attend the meeting and bring nonmember friends who would benefit from ACI association. All are welcome—there is no registration fee.

The dates of November 3 and 4 as originally announced have been dropped in favor of the later dates to avoid conflict with the Fall meeting of A.S.C.E. in Washington the week of October 30-November 5. A number of members will want to be at both meetings.

For those who plan to stop at the headquarters hotel, rates are quoted below. Make your reservations early.

Room rates at Hotel Kenmore, Boston, headquarters for ACI Regional Meeting:

Single rooms	$5.00-$ 8.00
Double rooms	$8.00-$12.00
Suites, single	$12.00
Suites, double	16.00

46TH

ANNUAL CONVENTION

February 20-22, 1950

CHICAGO

Edgewater Beach Hotel

We Want to Know—

ACI Members will recall that the membership classification forms circulated last year contained a question—"What suggestions have you for the Technical Activities Committee as to papers or reports you'd like to see published; subjects you'd like to see discussed?"

One thing that will undoubtedly develop from the many replies is a special session at the Institute's convention next February at which a panel of "experts" would head the discussion.

Meanwhile, the ACI JOURNAL will publish anonymously a good many of these questions and suggestions. Journal publication is intended to bring responses which may be the answer or partial answer to questions asked. Readers are not only invited to answer those questions appearing in print, but to send other suggestions and queries as well.

—Editor

Form removal

What is the recommended practice for form removal during winter concreting operations so as to minimize shock and subsequent cracking? (See "Recommended Practice for Winter Concreting Methods (ACI 604-48)"—Editor.)

Construction costs

I would like to see more articles on (1) construction methods and (2) articles or discussion on practical job cost accounting, some system which the average superintendent can understand and the average foreman, who must allocate daily charges, will not find too involved.

In 9 out of 10

I would especially like to see more attention given to form design since this is by far the most important cost factor in concrete construction—determining in 9 cases out of 10 whether concrete is to be used *at all*.

How to beat the game?

Currently there is a crying need for construction of highways, bridges, houses, etc. I would therefore like to read comments as to how we as engineers can accomplish best what we are expected to do. There must be a way to beat the game of "too much cost for too little result."

Research and practical application

I'd like to suggest that ACI Committees continue and intensify their efforts toward shortening the time-lapse between "Research and Development" and "Practical Field Application."

Acid effects on concrete

Are there any reports on the reactions of various food, fruit and industrial acids and chemicals on concrete and what remedies are suggested?

Cracks

How does one build concrete work that won't crack?

Column bar splicing

The splicing of column bars at the transition from one story to the next in beam and girder construction is sadly abused and of very doubtful efficiency as actually done. Several good articles are needed.

Control of contraction and shrinkage

How can the contraction and shrinkage in concrete be controlled? Uncontrolled cracks are our biggest problem.

Long span bridges

I would like to read about methods of construction in concrete bridges (pouring sequence, etc.), particularly on long continuous spans.

Continued on p. 31

Who's Who This Month

Committee 616

A new standard, "Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces (ACI 616-49)," approved by the Institute's 1949 convention and ratified by ACI members in a letter ballot canvassed June 29, leads off in the current volume, p. 1. It represents the work of Committee 616—G. E. Burnett, chairman, and his seven co-workers whose names head up the report.

J. R. Leslie and W. J. Cheesman

J. R. Leslie and W. J. Cheesman in their paper, "An Ultrasonic Method of Studying Deterioration and Cracking in Concrete Structures," p. 17, describe the results of several years work by the Hydro-Electric Power Commission of Ontario's Research Division. Originally described to the Institute at the Research Session of the 43rd annual convention, the "Soniscope" has resulted in a U. S. patent application.

Mr. Leslie is Research Engineer, Research Division of the Hydro-Electric Power Commission of Ontario and Mr. Cheesman is Assistant Research Engineer in the same organization.

Mr. Leslie graduated from the Univ. of Toronto in 1938 with an engineering physics degree. His ultrasonic experience stems from war work as a civilian scientist with the National Research Council, Ottawa, and the Minesweeping Section of the Admiralty, London, England. He has published several papers on electronics and physics in the A.I.E.E. publications and elsewhere. He is a member of the A.I.E.E.

Mr. Cheesman, also a graduate of the Univ. of Toronto in engineering physics, 1943, served as a radar officer with the Royal Navy. He has worked on development and application of the Soniscope since early in 1947.

I. T. Koudriashoff

Fast-moving world events, indefinite postal service and a shortage on the ACI staff during the war made it impossible to process the paper, "Manufacture of Reinforced Foam Concrete Roof Slabs," by I. T. Koudriashoff in 1939 when the first draft was received. Believing the material covered to still be of interest, the paper as finally revised appears on p. 37 of this issue.

Mr. Koudriashoff is Candidate of Technical Sciences, Scientific Collaborator of Concrete Laboratory of the Central Institute for Industrial Building Research, Moscow, USSR.

He describes the use of carpenter's glue in preserving air voids before the initial set of a Russian type of lightweight foam concrete, as well as production procedures for the manufacture of lightweight roof slabs.

Ernst Gruenwald

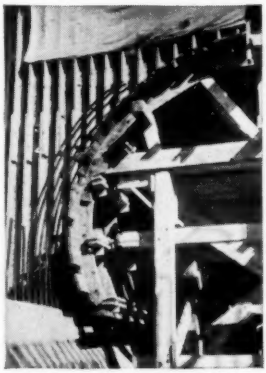
"Suggestions on Concrete Floor Construction," p. 49, by Ernst Gruenwald, continues the series of short articles on concrete floors.

Mr. Gruenwald, Manager, "Incor" Division and Technical Service, Lone Star Cement Corp., New York, N. Y., has been with the Lone Star Cement Corp. since 1926. He was in charge of concrete design until 1929. An associate of D. A. Abrams in concrete research, 1929-1932, he continued research in "Incor" high-early strength cement, being appointed to his present position in 1946.

Receiving his engineering degree from the Technical Univ. of Vienna in 1921, Mr. Gruenwald was engineer and superintendent for a construction firm in Vienna 1920-1923. As reinforced concrete designer for Southwestern Portland Cement Co., Osborn, Ohio and Colorado Cement Co., Denver, Colo., he designed silos, hoppers and varied plant structures

BUILDERS OF SAN ANGELO DAM USE HYDRON ON CURVED FORMS

Shown at the right is a tunnel section of the San Angelo Dam, San Angelo, Texas. The concrete was cast against Hydron Form Linings which provide a smooth, pit-free surface, enabling the concrete to withstand the grinding action of high-velocity silt-laden water.



Using a curved hinged form on the upper 300° with Hydron Form Linings. Hydron can also be used on lower 60°. After floating concrete apply Hydron and weight down with 2" of sand.

Hydron absorbs excess water and eliminates trapped air from the surface. This makes the concrete several times more resistant to abrasion and freeze-thaw conditions. The case hardening effect is gradual from the surface into the mass for about an inch.

Other big installations on which Hydron was used are: Fall River Dam, Norfork Dam, East Sidney Dam, Whitney Dam, Cherry Creek Dam, Soo Canal and lock walls, Chain O' Rocks Canal, Delaware & Chesapeake Canal bridge abutments, Maine Turnpike bridge abutments.

Contractors using Hydron report that the total cost including a satisfactory profit ranges from 12¢ to 16¢ per square foot.

For more information write Hydron Sales Department, United States Rubber Company, 1 Market Street, Passaic, N. J.

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before joining Lone Star Cement Corp. He is a member of A.S.T.M. Committee C-9, ACI and the Highway Research Board.

Published works include "Concrete Mix Design—A Modification of the Fineness Modulus Method," co-author with M. A. Swayze, ACI JOURNAL, Mar. 1947, and various other papers in A.S.T.M. *Proceedings, Civil Engineering* and *Pit and Quarry.*

J. J. Waddell

In his first ACI contribution, "Use of Air-Entraining Concrete in Canal Lining," p. 57, J. J. Waddell discusses air entrainment in concrete canal lining based on the studies made on air-entraining agents for the lining of the Friant-Kern Canal on the Bureau of Reclamation's Central Valley Project in California.

Mr. Waddell received his B.S. in engineering at the Univ. of Arizona in 1929. Before joining the Bureau of Reclamation in 1934, he was employed in various engineering capacities in Arizona and California. He was employed as a transitman and later as an inspector in the aggregate processing and concrete mixing plants at Parker Dam. Transferred to Shasta Dam in 1938, he was principal assistant in the laboratory until 1940, at which time he was appointed Assistant Concrete Control Engineer at Friant Dam. Mr. Waddell was made Concrete and Earthwork Control Engineer for the Friant-Kern Canal in 1945.

Wanted—A reviewer

A volunteer familiar with the Dutch language is needed to prepare reviews of articles in the magazine *Cement* published in Amsterdam. Current articles describe European practice in prestressed and reinforced concrete, reconstruction and specialized uses of concrete. Make your linquistic talents known to the Secretary.

Frank H. Powell

Frank H. Powell, president, Southwestern Portland Cement Co., Los Angeles, Calif., died of a cerebral hemorrhage July 6 at the age of 65. Mr. Powell, an ACI member since 1926, started his business career with Fairbanks, Morse and Co. He became associated with the Southwestern Portland Cement Co. in 1907, succeeding to the presidency upon the death of his father-in-law, Carl Leonhardt, in 1927. Mr. Powell, who was prominently known in the cement industry, was also a director of the Blue Diamond Corp., Los Angeles, and the Grand Canyon Lime and Cement Co. of Arizona.

Charles E. Fontaine

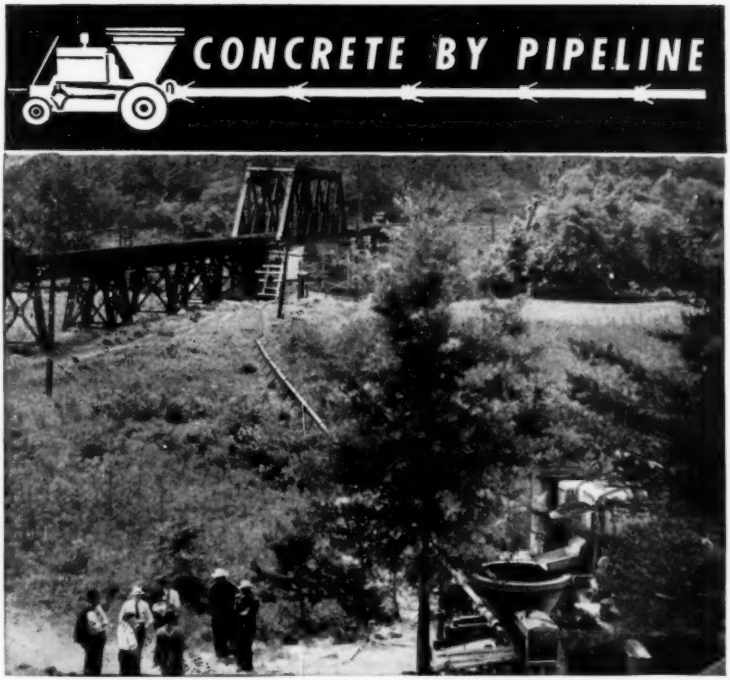
Charles E. Fontaine, vice-president of the Birmingham, Ala., Division of the Lone Star Cement Corp., New York, N. Y., died suddenly at his home in Mountain Brook, Ala. He had been an ACI member since 1938.

Francis R. MacLeay

Word has been received of the recent death of Francis R. MacLeay, ACI member since 1944. At the time of his death, Mr. MacLeay was assisting in a revision for publication of his Buffalo convention paper, "Thin Wall Concrete Ship Construction." He had resigned as chief engineer of the Corbetta Construction Co., New York City, to accept a position as chief engineer and general superintendent for John A. Johnson and Sons, Inc., of Brooklyn, N. Y.

Morris heads Public Power Assn.

Samuel Morris, general manager and chief engineer of the Dept. of Water and Power of Los Angeles, Calif., has been elected to the presidency of the Public Power Assn., a national organization.



Quality with Economy

Rex Pumpcrete, the pump that pumps concrete through a pipeline, assures highest quality concrete because it reconditions the mix . . . transports it in a sealed pipeline, thus eliminating segregation. The concrete arrives at the end of the pipeline in the same high-quality condition as when it left the reconditioning hopper. "Concrete by pipeline" provides an efficient, economical method of concrete placement.

For example, on this job the Pumpcrete was used to place concrete around the old masonry of two main railroad bridge piers. The Pumpcrete was installed on an existing spur track *450 feet* from the construction site, and the concrete pumped to the piers. It's typical of the ability of Pumpcrete to place concrete without interfering with traffic or other operations.

On this job, as on so many others where quality concrete and fast, economical placement are required, the engineers recommended the Pumpcrete method. For facts on the Pumpcrete method, write Chain Belt Company, 1713 W. Bruce St., Milwaukee 4, Wis.

CHAIN BELT COMPANY REX CONSTRUCTION MACHINERY

New Members

In publishing a list of 146 new ACI Members in the period May, June and July it is interesting to note that 48 of them are residents elsewhere than in the United States—98 domestic.

For the three-month period the State of Wyoming tops the list with 10 new Members; Venezuela is next with 9; Illinois and New York tied with 8 each; Canada has 7 new Members and England 5.

How is your state or country doing?

California

Carlson, Emil H., (Indiv.) 3117 Pearl St., Santa Monica, Calif.
Lindholm, R. R., (St.) 1029 Mariposa Ave., Berkeley 7, Calif.
Noble, H. Morgan, (Indiv.) Orange County Dock, Newport Beach, Calif.
Ramey, Robert H., (Jr.) 808 Campus Way, San Bernardino, Calif.
Samia, Benito O., (Indiv.) Atkinson & Jones Const. Co., APO 331, c/o P. M., San Francisco, Calif.

Colorado

Bullen, J. A. Jr., (Jr.) Fountain Sand & Gravel Co., P. O. 513, Pueblo, Colo.
Subramanyan, G., (Indiv.) c/o International Engineering Co., Inc., 510 Conoco Bldg., Denver, Colo.
White, Jack Douglas, (Indiv.) 7420 W. Twelfth Ave., Lakewood 15, Colo.

Delaware

Carlson, Walter, (Indiv.) 200 Pennsylvania Bldg., Wilmington 50, Del.

Florida

Hansen, Robert E., (Indiv.) 311 S.E. 16 Ave., Fort Lauderdale, Fla.
Jackson, Paul E., (Indiv.) 527 E. St., Clearwater, Fla.
Killgore, Ernest S., (Indiv.) 1400 Central Ave., St. Petersburg, Fla.
Wingerter, George E., (Indiv.) c/o Wingerter Laboratories, Inc., 660 N.W. 71st St., Miami 38, Fla.

Georgia

Lunoe, Reinhart R., (Indiv.) 412 W. 65 St., Savannah, Ga.
Marane, Alfred C., (Indiv.) Corps of Engineers, Clark Hill Dam, P. O. Box 915, Augusta, Ga.
Tarver, Jack P., (Indiv.) 1117 Anderson St., Bainbridge, Ga.

Idaho

Benoit, John James, (Indiv.) Lapwai, Idaho
Nelson, Thomas Earl, (Jr.) 1907 N. 12th, Boise, Idaho
Smith, John D., (Indiv.) c/o P. O. Box 1075, Idaho Falls, Idaho

Illinois

Akcaglilar, Necati, (St.) 806 W. Oregon St., Urbana, Ill.
Baldwin, John E., (Indiv.) 8020 S. Prairie Ave., Chicago 19, Ill.
Benmuvhar, Eddy Isak, (St.) 208 Talbot Laboratory, University of Illinois, Urbana, Ill.
Dieterich, De Witt, (Indiv.) 446 Evergreen St., Elmhurst, Ill.
MacLennan, John, (Indiv.) 5746 Hillcrest Rd., Downers Grove, Ill.
Mays, Jesse L., (Indiv.) 1929 Elizabeth St., Springfield, Ill.
Veletsos, Anestis, (St.) 207 Talbot Laboratory, University of Illinois, Urbana, Ill.
Williams, Richard Peter, (Indiv.) 6539 S. Kenwood Ave., Chicago 37, Ill.

Indiana

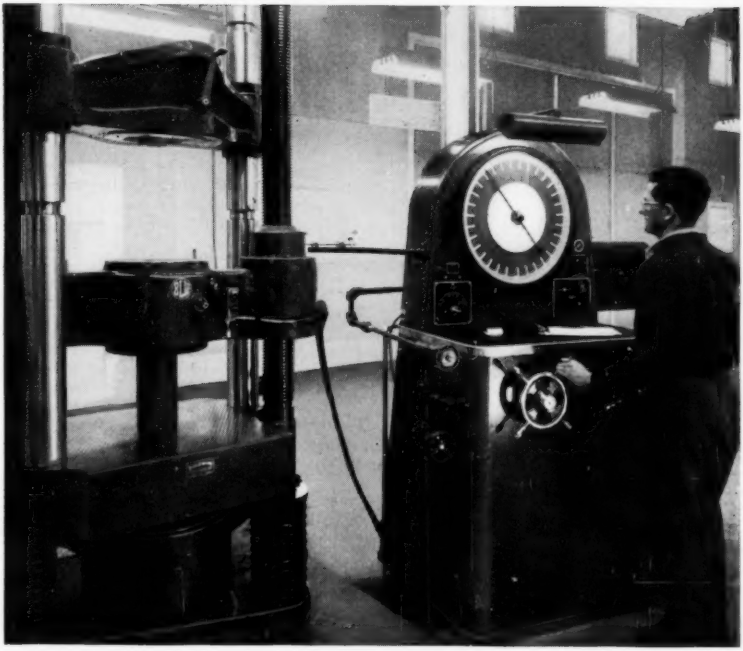
Blackburn, Jack B., (Indiv.) Research Assistant, Joint Highway Research Project, Purdue University, W. Lafayette, Ind.
Carlsen, C. E., (Indiv.) 2609 W. Alabama, Indianapolis, Ind.
Company, Sebastian, (St.) Box 115, University of Notre Dame, Notre Dame, Ind.

Iowa

Andrews, Raymond Truman, (Indiv.) Box 594, Mason City, Ia.
Dixon, Joseph H. Jr., (Jr.) Dept. of Civil Engineering, Iowa State College, Ames, Ia.
Hauser, Karl V., (Jr.) Marquette Cement Mfg. Co., 52nd & Park Ave., Des Moines, Ia.
Wilson, Edward N., (Jr.) Dept. of Civil Engineering, Iowa State College, Ames, Ia.

Kansas

Goodwin, Stanley E., (Indiv.) 1267 S. Minneapolis, Wichita, Kan.
Rees, Frank L., (St.) 658 Hercules Road, Sunflower, Kan.



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The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Boston, Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.

Louisiana

Fromherz, Thomas A., (Indiv.) c/o Fromherz Engineers, 427 Carondelet St., New Orleans 12, La.
Huey, S. E., (Indiv.) Consulting Engineer, Ouachita Bank Bldg., Monroe, La.

Maryland

Fendler, Benjamin J., (Indiv.) Arid Corporation, 206 W. Franklin St., Baltimore 1, Md.

Massachusetts

Lauer, Robert Hugh, (Jr.) c/o Thomas Worcester, Inc., 84 State St., Boston 9, Mass.
O'Connor, Thomas H., (Indiv.) 10 Cabot St., Milton, Mass.
Sevinor, Philip, (St.) 33 Gardner St., Chelsea 50, Mass.
Whelan, John E., (Indiv.) 105 Dorchester Ave., S. Boston 27, Mass.

Michigan

Chen, Chang-Hsien, (St.) 429 S. Division St., Ann Arbor, Mich.
Feser, Edward Louis, (Indiv.) 432 Fountain N. E., Grand Rapids, Mich.
Kaire S., Victor, (St.) 808 Oakland, Ann Arbor, Mich.
Kelso, Jack R., (St.) 1546 Marlboro Dr., Ann Arbor, Mich.

Missouri

Chappell, Carl James, (Indiv.) Syndicate Trust Bldg., St. Louis, Mo.
Ruscitto, George, (St.) 3635 Holmes St., Kansas City 3, Mo.

Nebraska

Garner, H. G., (Indiv.) Portland Cement Association, 504 S. 18th, Omaha, Nebr.

New Jersey

Drexler, Seymour, (Jr.) 90 Harmon St., Jersey City, N. J.
Phillips, E. W., (Indiv.) c/o Harrison Supply Co., Harrison, N. J.
Sunderland, Charles C., (Indiv.) 43 Cleremont Ave., New Brunswick, N. J.

New York

Barrie, William, (Indiv.) 16 Glover Ave., Yonkers, N. Y.
Hall, John F., (Indiv.) District Engineer, Portland Cement Association, 347 Madison Ave., New York 17, N. Y.
Hellerman, Isaac, (Indiv.) 1860 Broadway, New York 23, N. Y.
Kasperovich, William, (St.) 582 Crescent St., Brooklyn 8, N. Y.
Mianulli, Gennaro, (Indiv.) 4718 11th Ave., Brooklyn 19, N. Y.
Powsner, Michael, (Indiv.) 8821 17th Ave., Brooklyn 14, N. Y.
Shervington, George, (Indiv.) 252-35 Leeds Road, Little Neck, N. Y.
Siggelkow, John, (Indiv.) Oakridge Road, Mt. Kisco, N. Y.

North Carolina

Everhart, Eccles D., (Indiv.) Voorhees & Everhart, 116 N. Main St., High Point, N. C.
Van Wert, Paul H., (Indiv.) 701 Magnolia St., Winston Salem, N. C.

Ohio

American Steel & Wire Company of New Jersey, (Corp.) Rockefeller Bldg., Cleveland 13, Ohio (M. E. Capouch)
Ferguson, W. S., (Indiv.) 1910 E. 26th St., Cleveland 14, Ohio
Ross, F. B., (Indiv.) c/o Howe Construction Co., 215 Munroe Falls Ave., Cuyahoga Falls, Ohio
Selden, John K., (Indiv.) 310 Kingsbury, Maumee, Ohio

Oregon

Hogl, John M., (Indiv.) P. O. Box 1048, Portland 7, Ore.
Pyzdrowski, Henry A., (Jr.) Box 807, Bend, Ore.

Pennsylvania

O'Malley, William P., (Indiv.) 140 Victoria Drive, Pittsburgh 27, Pa.
Osisek, Paul T., (St.) 210 Prospect St., Phoenixville, Pa.
Potter, William Curtis, (Indiv.) 732 Orchard Terrace, Sewickley, Pa.
Schwendeman, Louis Paul, (Indiv.) 815 Merchant St., Ambridge, Pa.

South Carolina

Rowe, Gilbert H., (Indiv.) 1321 Bull St., Columbia, S. C.
Sanders, Wade M., (St.) Box 533, Gaffney, S. C.
State A & M College, (Corp.) Orangeburg, S. C. (Athelma R. Nix, Librarian)

South Dakota

Conger, Charles L., (Jr.) P. O. Box 124, Hot Springs, S. D.
Lynn, Kelso D., (Indiv.) 204 St. Andrews, P. O. Box 767, Rapid City, S. D.
Reifel, Alexander William, (Indiv.) Parmelee, S. D.

Tennessee

MacDaniel, John E., Jr., (Indiv.) Marquette Cement Mfg. Co., Union Planters National Bank Bldg., Memphis, Tenn.
Sumner, Billy T., (Jr.) 404 Cotton States Bldg., Nashville 3, Tenn.

Meets ASTM Specification A305

BETHLEHEM STEEL

Tests have demonstrated that proper deformations on reinforcing bars reduce cracking of reinforced concrete, and often eliminate the need for end hooks. To promote better performance of reinforced concrete, the industry has followed up these tests by developing ASTM Specification A305, which defines minimum requirements for reinforcing-bar deformations.

Keeping pace with the current demand for more positive deformations on concrete reinforcing bars, Bethlehem is now furnishing an improved reinforcing bar which easily meets the requirements of the specification. The new Bethlehem bar has high, alternately sloped cross lugs to assure maximum mechanical grip in concrete. The lugs are also closely spaced, to quickly transfer tensile stresses from the concrete to the steel. Thus shorter laps are possible.

The improved Bethlehem Reinforcing Bar is made from new billet steel, and comes in all sizes from ⅜ in. to 1¼ in. Full details are available from the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

Bethlehem Reinforcing Bars

Texas

Foster, John P., (Indiv.) 1002 Mills Bldg., El Paso, Texas

Utah

Austin, Howard Glenn, (Jr.) 550 N. 8th E., Provo, Utah.

Virginia

Butler, Robert Pendleton, (St.) Box 587, Orange, Va.

Sturgeon, Myron A., (Indiv.) 2124 Kimball Terrace, Norfolk, Va.

Washington

Ross, Robert W., (Indiv.) Box 206, Kennewick, Wash.

Wisconsin

Olson, O. Neil, (Indiv.) 1515 W. Wisconsin Ave., Milwaukee 3, Wis.

Simandl, Jos. J., (Indiv.) c/o Law, Law, Potter & Nystrom, 121 S. Pinckney St., Madison 3, Wis.

Wyoming

Allen, William Lewis, (Jr.) P. O. Box 189, Cody, Wyo.

Clark, Kyle Gregg, (St.) P. O. Box 483, Laramie, Wyo.

Goodrich, William W., (Indiv.) Wheatland, Wyo.

Lloyd, Kennth Gould, (St.) 210 Patton St., Laramie, Wyo.

Mills, Richard Dean, (Jr.) Lusk, Wyo.

Oliver, Robert E., (Jr.) Box 273, Riverton, Wyo.

Oshel, Ben H., (Jr.) 408 S. 5th St., Laramie, Wyo.

Pappas, Andrew, (Jr.) 1221 E. 20th St., Cheyenne, Wyo.

Sanders, Clifford J., (Jr.) 443 Gladstone, Sheridan, Wyo.

Webb, Melvin, (Jr.) 307 Angle St., Rock Springs, Wyo.

Canal Zone

Cagley, Leo W., (Indiv.) Box 421, Balboa Heights, Canal Zone

Thayer, Jira P., (Indiv.) P. O. Box 902, Balboa Heights, Canal Zone

Puerto Rico

Falcon, Eddie Lugo, (Indiv.) Box 6528, Loiza St. Station, Santurce, Puerto Rico

Lago, Jose A., (Indiv.) 413 Agueybana St., El Vedado, Hato Rey, Puerto Rico

Lairtus-Amoro's, George P., (Indiv.) 1402 Loiza St., Santurce, Puerto Rico

Argentina

Carriquiriborde, Pedro J., (Indiv.) Lab. de Ensayo de Materiales e Investigaciones, Tecnologicas (LEMIT) Ministerio de Obras Publicas, Calle 52, entre 121 y 122, La Plata, Argentina

Luis, Marcelia, (Indiv.) Calle Mareuol 130-II-B, Buenos Aires, Argentino.

Milan, Blazic, (Indiv.) Calle Malabia 2231-Ip.-D, Buenos Aires, Argentina

Australia

Clayton, Kenneth W., (Indiv.) c/o The National Bank of Australasia, Collins St., Melbourne, Australia

Canada

Breckon, Earl V., (Indiv.) 235 Avondale Ave. N., Hamilton, Ont., Canada

Coughlin, James, (Indiv.) 428 Dufferin St., Port Arthur, Ont., Canada

Hastings, Bruce Andrew, (Jr.) 596 Waterloo St., London, Ont., Canada

Laughlin, W. H. M., (Indiv.) Proctor, Redfern & Laughlin, 11 Jordan St., Toronto, Ont., Canada

Purdy, A. William, (Indiv.) Canada Cement Co., Ltd., 1103 Bank of Montreal, Toronto, Ont., Canada

Vye, D. M., (Indiv.) National Harbours Board, St. John, N. B., Canada

Wightman, Edwin Frederick, (Indiv.) 1025 W. 77th Ave., Vancouver, B. C., Canada

Colombia

Garzon, Alfonso, (Indiv.) Calle 22 No. 13-28, Bogota, Colombia, S. A.

Mendoza-Sonert, Pedro, (Indiv.) Colegio Segunda Ensenanza, Monteria Bolivar, Colombia, S. A.

Navarro, Alfonso Mejia, (Indiv.) Seccion Edificios Nacionales, Cartagena, Colombia, S. A.

Restrepom, William, (Indiv.) Apartado Aereo No. 49, Barranquilla, Colombia, S. A.

Egypt

Erfan, Ahmad, (Jr.) 57 Falaki St., Cairo, Egypt

Fouad, Hilmy, (Indiv.) P. O. B. 52, Mehalla El Koubra, Egypt

Sidarous, Ramsis, (Jr.) 4, Attaby St., Faggala, Cairo, Egypt

England

Drumm, James P., (Indiv.) 3 Jubilee Crescent, Bridgend Glamorgan, South Wales, England

Leech, Laurence A., (Indiv.) c/o Millars Machinery Co., Ltd., Thorley Works, Bishop's Stortford, Hertz, England

Pick, Zigmund, (Indiv.) 3, Greenfield Gardens, London N. W. 2, England

Continued on p. 32

Two practical ways to convey bulk cement...

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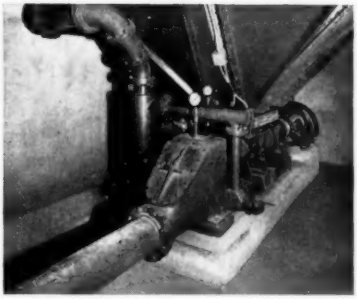
Right: Stationary Pump, installed in pit underneath track, unloading cement from hopper-bottom car.



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Positions and Projects — ACI Members

New standard and revised by-laws

By secret letter ballot ACI members ratified as an ACI Standard the "Proposed Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces." The standard as adopted is published on p. 1 of this JOURNAL.

Also ratified was a revision of By-Laws, Art. II, second paragraph, Sec. 13 to read "The Vice Presidents, each in the order of his seniority in that office, shall discharge the duties of the President, in his absence."

Richart, Gonnerman, Withey named A.S.T.M. officers

Three past presidents of ACI were named as 1949-1950 A.S.T.M. officers at the Fifty-Second A.S.T.M. Annual Meeting in Atlantic City, N. J. Frank E. Richart was elected Vice-President of the society; Harrison F. Gonnerman and M. O. Withey were elected to positions on the Board of Directors.

Prof. Richart, Research Professor of Engineering Materials, Univ. of Illinois, Urbana, Ill., is a past member of the ACI Board of Direction and was president in 1939. He has just completed a term as a director of A.S.T.M. and has also been active in the work of Committee C-9 on Concrete and Concrete Aggregates, Committee C-3 on Brick and numerous administrative committees.

He received the degree of B.S. in Civil Engineering from the Univ. of Illinois in 1914, later receiving his M.S. and C.E. degrees. Prof. Richart held various engineering positions in railway and public utility work before joining the Department of Theoretical and Applied Mechanics at Illinois in 1916. Since 1926 he has been in charge of the concrete research laboratory and graduate teaching in concrete.

In addition to A.S.T.M. and ACI, he is a member of the following organizations: A.S.C.E., Western Society of Engineers, Society for Experimental Stress Analysis and Highway Research Board. Prof. Richart has also served as a member of the Intercollegiate (Big Ten) Athletic Conference for many years and is at present chairman of the body.

Mr. Gonnerman, Assistant to the Vice-President for Research and Development, Portland Cement Assn., Chicago, Ill., was named to the A.S.T.M. Board of Directors after serving on Committee C-1 on Cement, Committee D-4 on Road and Paving Materials and Committee E-1 on Methods of Testing for many years.

A past president of ACI, 1946, he is also affiliated with A.S.C.E., American Assn. for the Advancement of Science, Western Society of Engineers and the Highway Research Board.

Mr. Gonnerman attended the Univ. of Illinois, receiving his B. S. degree in 1908 and M. S. in 1913. He served in the Engineering Experiment Station, Univ. of Illinois, and later was instructor in theoretical and applied mechanics. Mr. Gonnerman was Associate Engineer, Structural Materials Research Laboratory, Lewis Institute, and Research Laboratory of the Portland Cement Assn. He was Director of Research of the latter prior to his present position with the association.

Prof. Withey, Dean of the College of Engineering, Univ. of Wisconsin, Madison, Wis., was active on Committee C-9 on Concrete and Concrete Aggregates, Committee D-7 on Wood and several research and testing committees prior to his election to the A.S.T.M. Board of Directors.

He is a past president of ACI, 1943, and was formerly president of the Wisconsin Society of Professional Engineers. His other memberships include the A.S.C.E., National Society of Professional Engineers and the American Society for Engineering Education. In

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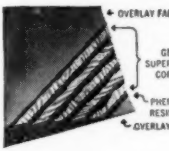

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1947 he was awarded the Turner Medal by ACI "in recognition of forty years of outstanding contributions to our knowledge and understanding of concrete and reinforced concrete."

Prof. Withey studied at the Thayer School of Civil Engineering, Dartmouth College, receiving his B.S. and C.E. degrees in 1904-1905. He was an instructor in the Mechanics and Materials Testing Laboratory, Univ. of Wisconsin, and later was Associate Professor of Mechanics. He became Professor of Mechanics in 1920 and headed the department beginning in 1934. He has been Dean of the College of Engineering since 1946.

Blanks honored

Robert F. Blanks, Head of Research and Geology Division, U. S. Bureau of Reclamation, Denver, Colo., received an honorary degree of Doctor of Science from his alma mater, Kansas State College, on May 29.

In conferring the degree on Mr. Blanks, Milton S. Eisenhower, President of the College and former classmate of Mr. Blanks, said in part: "In view of the outstanding contribution of Robert F. Blanks in the field of scientific and engineering development, it is fitting that this institution confer this honor upon him just 25 years after graduation. For the past 18 years he has been in charge of engineering research for the Bureau of Reclamation and in this post has been a key figure in the design and construction of such unprecedented structures as Hoover, Grand Coulee, and Shasta Dams. The developments which have come out of the engineering research laboratories of the Bureau of Reclamation, which he heads, have gained world-wide recognition and have contributed immeasurably toward making the world a better place in which to live."

An employee of the Bureau's Branch of Design and Construction since 1930, Mr. Blanks' outstanding work has been the development of laboratory and research techniques to solve diversified engineering problems. The engineering and geological laboratory under his direction has broadened its fields to become one of the largest laboratories of its kind in the world.

Mr. Blanks has been the recipient of many honors and awards from technical and professional societies, including the Thomas Fitch Rowland prize from the American Society of Civil Engineers given jointly to Mr. Blanks and Harmon S. Meissner, also of the Bureau. He was president of the American Concrete Institute during 1948 and is now a member of the Board of Direction of the Institute. He is also a member of important committees in A.S.T.M. and A.S.C.E. In April 1948 he was appointed Bureau representative on the Department of Interior Advisory Committee on Scientific Personnel.

Mr. Blanks has been active also in international professional affairs and has served on subcommittees of the World Power Conference and the International Commission on Large Dams.

In addition to the degree of B.S. in C.E. from Kansas State College, he holds also a professional civil engineering degree from the same institution.

New members added to Committee 323

Recent additions to Committee 323—Prestressed Reinforced Concrete, are Curzon Dobell, Preload Enterprises, Inc., New York; Charles C. Sunderland, Chief Engineer, Bridge Division, John A. Roebling's Sons Co., Trenton, N. J.; and Franklin R. McMillan, Consulting Engineer, Hinsdale, Ill. (formerly with PCA).

ACI Committees linked

Recognizing the close relationship between Committee 323—Prestressed Reinforced Concrete and Committee 324—Precasted Reinforced Concrete Structures, ACI Technical Activities Committee has appointed A. E. Cummings and A. Amirikian, chairmen, members of the other's committee.

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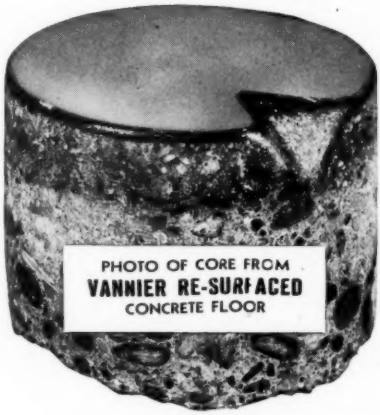

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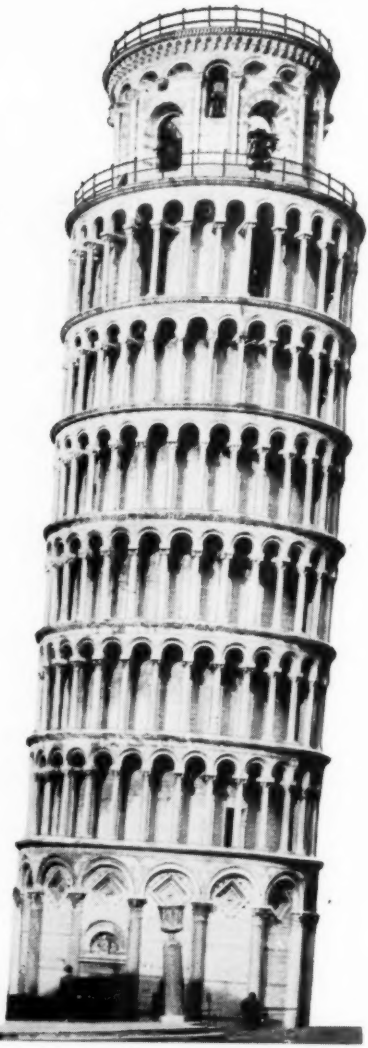

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Committee 207

Robert F. Blanks, Head of Research and Geology Division, U. S. Bureau of Reclamation, Denver, Colo., has been appointed chairman of Committee 207, Properties of Mass Concrete, to succeed Raymond E. Davis who resigned. The committee is in the process of reorganization.

Committee 704

Committee 704 has been reactivated and the personnel is being reorganized under the chairmanship of Otto Buehner, Salt Lake City, Utah, to review the present ACI standard for cast stone.

Lyse discusses airport runways at A.S.T.M. meeting

Inge Lyse, Norway Institute of Technology, discussed concrete for airport runways and suggested a novel method of construction at the 1949 annual meeting of A.S.T.M. at Atlantic City, June 27 to July 2. An ACI member since 1926 and a Director in 1937-38, Professor Lyse was intimately connected with column tests at Lehigh Univ. His work has been reported in 13 ACI JOURNAL papers over a period of 18 years.

Thompson Award to Mielenz and Witte

The Sanford E. Thompson Award, in recognition of a paper of outstanding merit on concrete and concrete aggregates, was given by the American Society for Testing Materials to R. C. Mielenz and L. P. Witte of the U. S. Bureau of Reclamation for their paper on "Tests Used by the Bureau of Reclamation for Identifying Reactive Concrete Aggregates."

The award was established by A.S.T.M. in honor of the late Sanford E. Thompson, first Chairman of Committee C-9. Mr. Thompson was a pioneer member of ACI and served as vice-president from 1917-19.

Doctorate to A. Burton Cohen

A. Burton Cohen, consulting engineer, received the honorary degree of Doctor of Engineering from Purdue Univ. in recognition of his outstanding professional achievement and a distinguished record of public service.

In private practice since 1920, Mr. Cohen has specialized in the design and supervision of construction of bridges and grade crossing eliminations in New York and nearby states. He has made a particular study of correlating design and construction considerations of concrete bridges, and in maintenance of highway and railroad traffic during construction. Current work includes the preparation of general plans for the elimination of all grade crossings in the city of Niagara Falls and contract plans and specifications for a bridge over the Susquehanna River at Johnson City, N. Y.

Mr. Cohen is the author of a number of ACI papers; the first entitled, "Progress

and Development of Concrete Work on the Delaware Lackawanna and Western Railroad," was presented in 1914 at the 10th annual convention. The latest, "Repairs to the Spruce Street Bridge, Scranton, Pa.," was presented at the 43rd annual convention in 1946. He was awarded the Wason Medal for the most meritorious paper in 1926 for his contribution, "Correlated Considerations in the Design and Construction of Concrete Bridges."

Mr. Cohen has been a member of ACI since 1910; a member of the Advisory Committee from 1924-30; and of the Board of Direction, 1942-44.

After graduation from Purdue in 1905, Mr. Cohen was for 15 years a civil engineer for the Lackawanna Railroad. For ten years he was Concrete Bridge Engineer in charge of the design of concrete bridges which included the supervision of more than 200 grade separations.

Research information desired

The assignment of Committee 115, Research, "is to review and correlate research in concrete and reinforced concrete and to consider research methods and objectives." The committee has attempted to fulfill this assignment through the Research Sessions at the annual conventions, through the distribution of the annual compilation of research projects underway at the various laboratories and through limited correspondence among committee members.

From the continuing interest of the ACI membership in the activities of Committee 115, it is evident that real needs are being met. It would be presumptuous, however, to assume that the committee has reached the zenith of its possible usefulness; there must be various respects in which increased service can be rendered. Reactions and suggestions for greater usefulness are earnestly requested; perhaps there are laboratories or projects which have been overlooked; perhaps there are questions that should be raised or additional activities that should be started. Since the committee is anxious to have complete coverage of all research projects in its next compilation, all persons having suggestions or knowing of omissions are urged to initiate correspondence at once. No publicity will be given any information without the permission of the correspondent. Address your suggestions and inquiries to:

Prof. Geo. W. Washa, Secretary
ACI Committee 115
Education-Engineering Building
University of Wisconsin
Madison 6, Wis.

Gruenwald speaker at Pan-American Engineering Congress

Ernst Gruenwald, manager, "Incor" and Technical Service Dept., Lone Star Cement Corp., New York, N. Y., presented a paper, "Some Recent Concrete Developments in the U. S. A.," at the First Pan-American Engineering Congress at Rio de Janeiro, Brazil, in July. He toured several other South American countries and stated that reinforced concrete is the major building material used in those countries.

Award to PCA publication

In the first Product Literature Competition sponsored jointly by the Producers' Council, Inc. and the American Institute of Architects, a certificate of merit was presented to the Portland Cement Assn. for its booklet "Design and Control of Concrete Mixtures." The major purpose of the competition is "to help stimulate better and more technical data for architects from manufacturers of building products."

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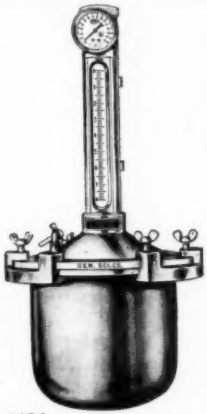

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Walter named regional engineer

Donald S. Walter, construction engineer on the Anderson Ranch Dam in the Boise River Basin of Idaho, has become regional engineer for the Bureau of Reclamation at Boise. Walter held key positions in the construction of Hoover, Grand Coulee and Friant dams.

Corbettas join housing corporation

Roger and Louis Corbetta, principals of the Corbetta Construction Co., specialists in concrete construction, have been elected vice-presidents in charge of the construction division of Ibec Housing Corp. Emil H. Praeger, partner in the firm of Madigan & Hyland, and consultant to the United Nations on its headquarters under construction in New York City, has been appointed consulting engineer of the corporation, which is working on a low-rent housing project in Norfolk, Va.

Weiner in new post

Albert Weiner, formerly in charge of the concrete laboratory of the U. S. Concrete and Soils Laboratory, Ithaca, N. Y., has transferred to the North Atlantic Division, Corps of Engineers, where he has general supervision of projects and district control of laboratories and construction methods relating to concrete in several Eastern seaboard states.

Perlite Institute elects Carter

T. C. Carter, vice-president of the Great Lakes Carbon Corp. and general manager of the Building Products Division has been elected President of the Perlite Institute.

Mr. Carter was one of the organizers of the National Mineral Wool Assn. in 1934 and subsequently served this association three times as president. He organized the Industrial Mineral Wool Institute in 1941.

The Perlite Institute is a nonprofit organization representing eighteen manufacturers of Perlite lightweight insulating aggregate.

Friel honored

Francis S. Friel, president of the Philadelphia, Pa., consulting firm of Albright & Friel, recently received an honorary doctor of engineering degree from Drexel Institute of Technology. Dr. Friel was cited for his "notable contributions to the health and property of our people through his skill in sanitary technology, and to the security and well-being of our country through his public service in peace and war....."

Wilson awarded Marston Medal

Prof. Wilbur M. Wilson, ACI Wason Medalist, was named the Marston Medalist for 1949 during June ceremonies at Iowa State College, Ames, Ia., in recognition of outstanding achievement in engineering.

Prof. Wilson is widely known for his research work in the field of structural engineering. His applications of the slope-deflection method to the analysis of statically indeterminate structures have been recognized as a major contribution to the literature of structural engineering. He has specialized on the testing of structures and structural members, including the development of laboratory apparatus which would subject structural members to the same loading conditions as a member of a structure in service. Prof. Wilson has devoted a major portion of his time to the determination of the fatigue strength of structural members under repeated loadings.

On two occasions, the Western Society of Engineers awarded him the Chanute Medal and he was also awarded the James J. R. Croes Medal of the A.S.C.E. He received the Wason Medal for most meritorious paper of the American Concrete Institute for co-authorship with Ralph W. Kluge of "Tests of Rigid Frame Bridges," ACI JOURNAL, May-June 1938. He served as a director of A.S.C.E. from 1944 to 1947 as well as being a member of many other engineering societies.

He graduated from Iowa State College in 1900 with the degree of Bachelor of Mechanical Engineering. Iowa State conferred on him the professional degree of Civil Engineer in 1914 and the honorary degree of Doctor of Engineering in 1942. He received the degree of Master of Mechanical Engineering from Cornell Univ. in 1904.

Since 1922 Prof. Wilson has held the position of Research Professor of Structural Engineering in the Civil Engineering Department at the Univ. of Illinois. Prior to that he served at Iowa State College and practiced structural engineering in Chicago.

The Marston Medal is awarded to an engineering alumnus of Iowa State College in recognition of achievement in engineering. The award was established by the college in 1938 honoring Dean Emeritus Anson Marston who was Professor of Civil Engineering from 1892 to 1920 and Dean of Engineering from 1904 to 1932.

Laude appointed vice-president

Clarence L. Laude has been appointed vice-president in charge of sales for the Huron Portland Cement Co., Detroit, Mich., and H. Ripley Schemm has been named vice-president in charge of operations.

Loveland appointed superintendent

Russ A. Loveland, research engineer for the Portland Cement Assn., Chicago, Ill. has returned to the Pennsylvania-Dixie Cement Corp., Easton, Pa., as superintendent of Plant No. 4 at Nazareth. Mr. Loveland started his career in the cement industry in 1920 as mix chemist at the Hanover, Mont., plant of the Three Forks Portland Cement Co. He left there a few months later to attend the Univ. of Chicago returning as an assistant chemist in 1923, working alternately at the Hanover and Trident, Mont., plants. Two years later he became associated with the Clinchfield Portland Cement Co., Clinchfield, Ga. (now a part of Penn-Dixie) as assistant chemist. Subsequently he joined the Dewey Portland Cement Co., Kansas City, Mo., serving as plant chemist,

plant engineer, chief chemist and research engineer at the Dewey, Okla., and Davenport, Ia., plants, from 1926 to 1944. Mr. Loveland relinquished this connection to accept a position as production manager for Cemento Portland Moctezuma, S. A., Cuernavoca, Morelos, Mexico. A year later he joined the Marquette Cement Manufacturing Co. as assistant to the technical director. From June, 1947, to the present time he has served the Portland Cement Assn. as research engineer in the manufacturing research section.

Ward appointed to research staff

George W. Ward has recently been appointed to the Research Staff of Gustin-Bacon Manufacturing Co. He was previously with the Midwest Research Institute of Kansas City, Mo.

N.R.M.C.A. and N.S.G.A. get new laboratory

The National Ready Mixed Concrete Assn. and the National Sand and Gravel Assn. have moved into their new laboratory in Building H of the Martin Engineering College, Univ. of Maryland. It has been located in the Arts and Science Building for the past 12 years. New equipment has been installed, several major pieces being for freezing and thawing tests of concrete.

Reardon views European floors

William J. Reardon, president of Reardon Industries, Inc., Cincinnati, Ohio, makers of colors for terrazzo and concrete, is touring Italy, France, Ireland, England, Portugal and Switzerland for the purpose of observing the construction of concrete floors in monumental buildings.

Mr. Reardon is a member of the Board of Trustees of the Ohio Turnpike Committee, American Concrete Institute, American Chemical Society and the Cincinnati Engineering Society.

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Savage visits Near East

J. L. Savage, consulting engineer of Denver, Colo., and world authority on large dams, is presently engaged in engineering work in Turkey and Israel.

Joint Committee Report in demand

More than 27,000 copies of the Joint Committee Report "Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete," now in its fifth printing, have been issued. Of this total over 15,000 have been distributed by ACI, the balance by P.C.A. and A.S.T.M.

John E. Kelly

John E. Kelly, formerly proprietor of the Empire Pre-Cast Concrete Co., Inc., Denver, Colo., is now a materials and structural engineer with the Eidal Manufacturing Co. of Albuquerque, N. M., manufacturers of reinforcing steel and accessories.

Qureshy returns to Pakistan

Asrar A. Qureshy after completing two years of study at the State Univ. of Iowa, has returned to Lahore, Pakistan, where he will become design engineer in the Irrigation Branch of the West Punjab Provinces government. Mr. Qureshy will be responsible for the construction and maintenance of irrigation and hydroelectric works in that province.

Inspect Pa. toll bridges

George S. Richardson, consulting engineer, of Pittsburgh, Pa., has been appointed to make an inspection of the last ten privately owned toll bridges in Pennsylvania. This is the state's first move toward buying and freeing the bridges in accordance with a new law allowing use of a $10,000,000 bond issue for that purpose.

Haertlein receives doctorate

Albert Haertlein, Gordon McKay Professor of Civil Engineering at Harvard, received an honorary doctor of science degree from Northeastern Univ. in Boston at commencement exercises on June 26. His citation read, "Distinguished civil engineer, authority in the design of structures, counsellor to aspiring youth, you have committed your talented mind and generous heart to the advancement of a great profession. Northeastern is happy to recognize a prodigious worker whose selfless spirit evokes admiration and affection among colleagues throughout the field of engineering."

Concrete reduces small home costs

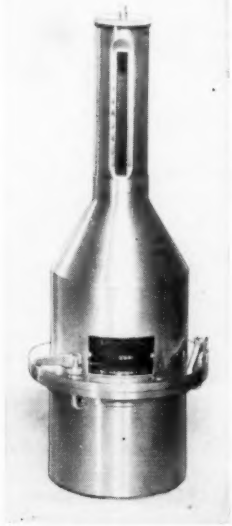
Elimination of basements in small houses to save costs is bringing increased use of concrete pier and grade slab foundations among New York builders, according to Housing and Home Finance Agency reports. For best results in cooler climates, it is recommended that the crawl space under a house resting on piers be enclosed with skirting and that concrete slab floors be insulated. Skirting can be of concrete precast in sections on the site or in a plant. Set in place carefully, the skirting forms part of the foundation.

Other methods of lowering costs suggested by the FHA include an on-edge insulated concrete floor, designed particularly for the basementless house in the colder climates. This flooring is slab on ground, with a concrete trench footing designed to take advantage of both bearing resistance and skin friction.

Another economy being accepted by local FHA offices under the Economy Housing program is the use of unfurred walls constructed of 8 x 8 x 16-in. pumice blocks provided the exterior of the wall is waterproofed.

ACI visitor

Karl G. Ekblad, M.C.E., a Fellow of the American Scandinavian Foundation, paid a brief visit to ACI Headquarters on July 21. Mr. Ekblad is spending about a year in the United States studying engineering and construction, especially concrete construction.



The ROLL-A-METER

A DEVICE FOR ACCURATELY MEASURING ENTRAINED AIR IN CONCRETE

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Specifications

Net weight.....18 lbs.
Height.....22 in.
Outside diameter at center.....8 in.
Volume of base.....130 cu. in.

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C.R.S.I. award to Ammann and Whitney

Charles S. Whitney, representing the firm of Ammann and Whitney, consulting engineers of New York and Milwaukee, on July 14 received the first Annual Award of the Concrete Reinforcing Steel Institute "in recognition of a noteworthy contribution to the advancement of reinforced concrete construction."

Whitney received the award on behalf of the firm for its paper entitled "Thin Shell Concrete Structures." Presentation took place at the 25th anniversary meeting of the Institute, held at White Sulphur Springs, West Va. July 14-16.

Members of the Award Committee based their selection on one or more of three points: research contributing to the advancement of reinforced concrete; noteworthy contributions to the theory of reinforced concrete design, or improvements to reinforced concrete construction practices. According to Prof. Frank E. Richart of Talbot Laboratory, Univ. of Ill., chairman of the present award committee, the Ammann and Whitney paper qualified on all three points.

According to Whitney the type of shell construction developed by the firm has made possible the use of reinforced concrete for long span roofs of such structures as hangars, sports arenas, bus terminals and large auditoriums at a much lower cost than has heretofore been possible. Main features are the use of slender hingeless reinforced concrete stiffening arches and the placing of the thin shell near the neutral axis of these arches. The use of slender arches reduces the bending and the abutment reactions due to volume changes and abutment displacements. Placing the shell near the neutral axis of the ribs affects considerable economy by reducing by 50 percent or more the stiffness of the arch rib, with a corresponding reduction in volume change effects.

Three examples of this type of con-

struction are the American Airlines Hangar at Chicago, the Alabama Livestock Coliseum at Montgomery, and the Onondaga County War Memorial Auditorium at Syracuse, N. Y.

To facilitate the construction of these large reinforced concrete shell roofs, the firm has also worked out the design of a special steel arch falsework. Although it had not been used at the time of submission of the paper, its estimated first cost is said by Whitney to be considerably less than that of timber falsework.

Mr. Whitney has had several papers published in the ACI JOURNAL. He was awarded the Wason Medal for most meritorious paper in 1932 for his article "Plain and Reinforced Concrete Arches." He was a member of the Board of Direction, 1945-46.

Other members of the selection committee, in addition to Professor Richart, who represented the American Society of Civil Engineers, were Henry C. Turner, Jr., President of the Turner Construction Co., New York, representing the Associated General Contractors of America, and Chester L. Post, Consulting Engineer of the Public Buildings Administration, representing the American Concrete Institute.

Hanson joins engineering firm

Thomas C. Hanson, who recently resigned as Detroit, Mich., commissioner of Public Works, has become a member of the civil engineering firm of Mason L. Brown and Son, also of Detroit. He will retain the position of president of the Detroit Rapid Transit Commission. Prior to his 17 months' service as commissioner, Mr. Hanson was head of the department of civil engineering at the Univ. of Detroit.

Annual reports of six cement manufacturers win awards

In the *Financial World* ninth annual survey of corporation annual reports those of Bessemer Limestone and Cement Co., General Portland Cement Co., Lone Star Cement Co., Marquette Cement Manufacturing Co., Missouri Portland Cement Co. and Permanente Cement Co. qualified for "Highest Merit Award" citations and became candidates for a "Best of Industry" award. Last year Marquette Cement Manufacturing Co. won the trophy in this industrial classification.

Lewis named to N.Y.U. chair

Robert L. Lewis, professor and head of the Civil Engineering Dept. of Colorado A. & M. College, has been named chairman of the Dept. of Civil Engineering of New York University's College of Engineering, effective September 1. For the past two years, Professor Lewis has also been chief of the civil engineering section at the Colorado Agricultural Experiment Station.

A.S.T.M. to meet on West Coast

The American Society for Testing Materials will hold its First Pacific Area National Meeting in San Francisco, Calif., Oct. 10-14. Following a brief opening session, Monday, Oct. 10, there will be 15 technical sessions through Thursday, Oct. 13, featuring the presentation of 70 papers. Included in the program and of interest to concrete engineers will be the symposium on use of pozzolanic materials in mortars and concrete.

ACI Synopses Leaflet
Vol. 45

Available for the asking

American Concrete Institute
New Center Building
Detroit 2, Mich.

Honor Roll

February 1, 1949 to July 31, 1949

272 names appear on this list of ACI Members to give evidence of various degrees of "Member consciousness". Plainly, being at the top of this list is a habit with the Morgans (father and son, Illinois and Wyoming) or are their geographical environments "concrete conscious"—or is it personal enterprise in meeting responsibilities of an organization founded on mutual effort? Menefee's and Sherlock's names speak for Michigan, Gilkey for Iowa, Mitrani and Vila for Cuba and Orozco for Mexico to round out the top eight notches on the Honor Roll for the period ending July 31, 1949.

Newlin D. Morgan	**42½**
Newlin D. Morgan, Jr.	**26**
F. N. Menefee	**11**
R. H. Sherlock	**6½**
Jaime Alberto Mitrani	**6**
H. J. Gilkey	**4**
J. Vicente Orozco	**4**
Jose Antonio Vila	**4**
Frank E. Richart	**3½**
Thomas E. Stanton	**3½**
Raymond E. Davis	**3**
John J. Hogan	**3**
H. D. Jolley	**3**
Barton Jones	**3**
J. W. Kelly	**3**
Leon Venegas	**3**
Stanton Walker	**3**
R. A. Caughey	**2½**
Roger H. Corbetta	**2½**
A. J. McElrath	**2½**
William T. Neelands	**2½**
Paul W. Abeles	**2**
J. F. Baxter	**2**
John G. Dempsey	**2**
Ambrosio R. Flores	**2**
Zorislav Franjetic	**2**
H. F. Gonnerman	**2**
Henry E. Griset	**2**
Emory E. Johnson	**2**
R. R. Kaufman	**2**
Karl W. Lemcke	**2**
Frederic L. Mavis	**2**
William S. Moore	**2**
William D. Nowlin	**2**
Luis Pardes-Manrique	**2**
Luis A. Pietri-Lavie	**2**
Dan H. Pletta	**2**
G. E. Troxell	**2**
Roberto Barillas F.	**1½**
Harold S. Carter	**1½**
S. J. Chamberlin	**1½**
H. C. Delzell	**1½**
Adly W. Gindy	**1½**
Adli Milik Hanna	**1½**
Elmo C. Higginson	**1½**
Robert L. Mauchel	**1½**
Carl A. Menzel	**1½**
Edward W. Scripture, Jr.	**1½**
Roy T. Sessums	**1½**
Thomas C. Shedd	**1½**
Calvin T. Watts	**1½**
Jerome O. Ackerman	1
William F. Anderson	1
Samuel Baker	1
J. A. Bakker	1
Charles F. Ball	1
John H. Bateman	1
Donald C. Beam	1
Oscar Benedetti	1
H. J. Bezette	1
Robert F. Blanks	1
Hans H. Bleich	1
Ernest M. Bowles	1
Carlos Mora Bravo	1
Milton Brumer	1
R. Y. Bush	1
Adraino Carbone	1
R. V. Chate	1
E. F. J. Clark	1
H. W. Comack	1
R. E. Copeland	1
Alirio Cornejo	1
Hendrik Cornelissen	1
W. S. Cottingham	1
G. H. C. Crampton	1
Jacob J. Creskoff	1
Ray A. Crysler	1
Jose A. Cuevas	1
Harmer E. Davis	1
Peter J. Doanides	1
A. T. Docal	1
W. H. Droege	1
C. Martin Duke	1
Belmon U. Duvall	1
Harlan H. Edwards	1
J. M. Faircloth	1
Ewell W. Finley	1
F. L. Fitzpatrick	1
George W. Ford	1
Robert W. Freeman	1
Carmelo Galindez	1
Gerald K. Gillan	1
Castor Segunda Goa	1
Ali N. Gokyigit	1
E. Gonzalez-Rubio	1
Armour T. Granger	1

Samuel J. Green 1
K. Hajnal-Konyi 1
Robert J. Hansen 1
Bernard C. Herring 1
M. D. Hicklin 1
Percy Howat 1
Franklin D. Howe 1
Myron A. Howe 1
J. W. Hubler 1
Alberto Dovali Jaime 1
J. P. Jain 1
V. P. Jensen 1
R. C. Johnson 1
Edgar R. Kendall 1
K. V. Kini 1
Ralph W. Kluge 1
Max Krueger 1
Blas A. Lamberti 1
George E. Large 1
William Lerch 1
Leslie D. Long 1
Winthrop E. Luke 1
Glenway Maxon 1
James A. McCarthy 1
Sam McCluer 1
H. J. McGillivray 1
George C. McLeod 1
F. R. McMillan 1
M. J. McMillan 1
Jesus Mesa 1
Robert B. B. Moorman 1
Robert Morris 1
R. F. Moss 1
George G. Nichols 1
LeRoy T. Oehler 1
Czeslaw Ozieblowski 1
Jose F. Perez 1
Anthony F. Pessolano 1
Charles Peterson 1
James M. Polatty 1
W. S. Powell 1
Emil Praeger 1
Raul Miguel Rivero 1
Albert Rootberg 1
John A. Ruhling 1
Emil Schmid 1
Saul Shaw 1
Isaac S. Shina 1
Ranbir Singh Shrikant 1
Richard Skalak 1
William Furber Smith 1
Luis G. Solano A. 1
Frederick E. Springate 1
Alois Starkmann 1
W. B. Summer 1
Manabu Tanaka 1
Maurice Taylor 1
T. W. Thomas 1
I. L. Tyler 1
Oscar J. Vago 1
Joseph J. Waddell 1
Bertrand H. Wait 1
Stanton Walker 1
John M. Wells 1
J. G. Welsh 1
Frank W. Wheeler 1
George Winter 1
Donald K. Woodin 1

The following credits are, in each instance "50-50" with another member.

Birger Arneberg
Michel Bakhoum
C. Harold Barcus
Charles H. Barker
Hugh Barnes
Frank Baron
J. F. Barton
J. E. Bates
Aaron H. Bauman
E. W. Bauman
R. W. Brandley
A. H. Brewer
Harold W. Brewer
A. R. Brickler
Robert G. Burnett
J. A. Carrick
Napoleon V. Campomanes
Arthur P. Clark
Leo Coff
R. D. Conrow
W. A. Coolidge
Leo H. Corning
Dwight A. Covington
Lauro M. Cruz
A. E. Cummings
M. H. Cutler
W. A. Davis
Curzon Dobell
Ernest A. Dockstader
A. H. Douglas
W. J. Emmons
J. L. Faisant
A. V. Farley
Phil M. Ferguson
Benjamin Forsyth
A. W. Haddow
J. R. G. Hanlon
W. S. Hanna
M. J. Hawkins
A. E. Hiscox
Albert C. Hooke
S. E. Hyde, Jr.
Melvin Fu Hoon Ja
Bruce Jameyson
Bruce M. Johnson
Samuel Judd
Frank Kerekes
Lane Knight
Carl A Koerner
James V. Mandia
Henri Marcus
Hudson Matlock
J. W. McBurney
T. R. McCullough
Jack Robert Miller
Wm. Morris
S. Neatwait
Philip M. Noble
Calvin C. Oleson
George L. Otterson
Chester B. Palmer
Douglas E. Parsons
Robert J. Perrich
George Nelson Perry
Alan H. Pilling
Warren Raeder
Irvin S. Rasmusson
F. V. Reagel
Francisco M. Rexach
William H. Rowan
Fred H. Ryan
Cecil F. Schaaf
Jack S. Short
Ruben Ruiz Silva
Tirlochan Singh
Charles A. Snyder
H. F. Sommerschield
G. W. Stokes
E. Q. Sullivan
E. O. Sweetser
Anton Tedesko
William H. Thoman
J. Trueman Thompson
E. W. Thorson
LeRoy A. Thorssen
Homer Thrall
Fehiman Tokluoglu
Gregory Tschebatarioff
John Tucker, Jr.
Maxwell Upson
F. E. Votaw
Norman Wagner
W. Wayne Wallace
M. H. Walters
David Watstein
J. C. Watt
W. R. Waugh
Carl Weber
Charles S. Whitney
H. F. Williams
Paul C. Winters
Thomas Worcester
K. W. Wright
Charles E. Wuerpel
Alexander H. Yeates
R. B. Young
Robert Zaborowski

Are
YOU
"Member conscious"?

We Want to Know

Continued from p. 5

Slab strength

What effect do conduits, sleeves, etc. in slabs have upon the strength of the slab?

Equipment data

Why not a good informative article giving data on the operation of equipment such as pumpcretes and slip-forms?

Form design

I would like to see an article on form design, *i.e.*, bracing, types of form material, stresses that occur in forms and placing of different types of ties.

Construction

How about some descriptions of construction projects, with careful reference to the problems of converting designs into finished structures?

Construction costs

Current concrete construction costs and estimating data would, I believe, make a worthwhile series of articles.

How high?

Does altitude influence the casting of concrete?

Precasting and prestressing

Descriptive articles on practical applications of precasting and prestressing in building construction would be appreciated.

Construction details

More information is needed on the details of concrete construction, such as formwork and field control of concrete.

Repairs

How about some hints on repairs to concrete structures?

Causes of failure

What are the major (and minor) causes of failures in concrete construction and methods of avoiding such mistakes in the future?

Tilt-up construction

Tilt-up construction has too often been described from the "popular" view, and not from the design and engineering standpoint.

Operating cycle of two-batch trucks studied

Hauling unit studies made on two-batch trucks on portland cement concrete paving projects by the Highway Research Board Committee on Economics of Highway Construction and Maintenance Methods show that each truck spends a total of slightly over 12 min per trip in the batch plant, at the paver, and in miscellaneous waits and delays. The average road speed was observed to be between 20 and 25 mph.

These data were obtained from studies made by the Production Cost Unit of the Public Roads Administration on 7 different projects in the eastern and southern United States over the past 18 months. About 80 trucks were observed for a total of 950 truck-hours of operation.

The average time for each of the major elements of the two-batch truck cycle was: time in batch plant, per trip, 4.24 min; time at paver, per trip, 2.48 min; minor waits and delays per trip, 5.45 min. The average haul distance was 2.11 miles; haul speed, loaded, 21.1 mph and return speed, empty, 23.5 mph.

Average haul and return speeds in excess of 30 mph were obtained on only one job; the speeds on the other 6 jobs ranged from 16.6 to 29.3 mph over paved or reasonably well graded earth roads. On the job which had the highest average speed, 31.0 mph loaded and 37.3 mph empty, the hauling was done over a level and newly paved road closed to traffic.

The exchange time at the paver is the interval of time from the moment one truck drives off the skip after having dumped its second batch until the moment the next truck backs up onto the skip. This is a very critical time interval that should be reduced to a minimum, particularly on dual drum paver operations, stated the report.

The committee also made two studies on three-batch trucks. It was found that each truck spent about 5.5 min in the batch plant and 4.0 min at the paver on each trip.

New Members

Continued from p. 14

Trafford, Thomas C. L., (Indiv.) 3 Seymour Grove, Old Trafford, Manchester, England

Windfeld-Hansen, Preben, (Jr.) c/o Ove Arup & Partners, Colquhoun House, Broadwick St., London W. 1, England

Finland

Janhunen, Matti, (Indiv.) Keskuskatu 5. F., Helsinki, Finland

France

Societe Technique pour L'Utilisation de la Precontrainte, (Corp.) 5 Rue Beaujon, Paris (8°) France

Honduras

Zablah, Jose, (St.) Apartado Postal No. 62, Tegucigalpa, D. C., Honduras, C. A.

India

Bishnoi, Anand Singh, (St.) c/o Dr. H. B. Singh, M. B., B. S., P. O. Khairabad (Avadh) District Sitapur, U. P., India

Gill, Rachhpal Singh, (Indiv.) Ellerslie, Irrigation Secretariat, Simla E., East Punjab, India

Roy, N. C., (Indiv.) Dalmia Cement Ltd., Scindia House, New Delhi, India

Mexico

Alduvin Abaunza, Ricardo, (Indiv.) Puebla 288-E., Mexico D. F., Mexico

New Zealand

Clark, Richard E., (Indiv.) Public Works Department, Karapire, Cambridge, N.Z.

Philippines

Morales, Basilio M., (Indiv.) 2033 Ilustre, Sta. Cruz, Manila, Philippines

Salvador, El

Notarbartolo, Leopoldo, (Indiv.) Apartado Postal 170, San Salvador, El Salvador, C. A.

South Africa

Paulo, Mieczyslaw Marian, (Indiv.) 12, Serpentine, Pinelands, Capetown, S. Africa

Venezuela

Andreasen, Knud Henning, (Indiv.) c/o Black, Edf. Maderero, 3. Floor, Esq. Maderero, Caracas, Venezuela

Fuenmayor, Antonio J., (Indiv.) San Rogue a San Martin No. 58, Caracas, Venezuela

Garcia del Diestro, Alberto, (Indiv.) Edificio la Ceiba (6° piso) San Francisco a Sociedad 8, Caracas, Venezuela

Gonzalez, Gerardo, (Indiv.) Los Rosales, Avenida El Paseo, Quinta Santa Ana, Caracas Venezuela

Marimon B., Jose, (St.) Av. Casanova, Quinta. Pirineos, Urb. Bello Monte, Caracas, Venezuela

Martinez de la Plaza, Celestino, (Indiv.) Avenida La Floresta No. 11, Sabana Grande, Caracas, Venezuela

Reti, Andres, (Indiv.) La Florida, Avenida del Bosque, Quinta Silesia, Caracas, Venezuela

Rodriguez-Delfino, Alfredo, (Jr.) Escuela De Ingenieria, Ciudad Universitaria, Caracas, Venezuela

Rogers, Alfred A., (Indiv.) c/o J. G. White, Las Piedras Estado Falcon, Venezuela

Tools, Materials, Services

Under this heading note will be made from time to time of producer literature of presumed technical interest (and available from its source for the asking) to ACI users of tools, equipment, materials, accessories and special services.

Cellular glass insulation

A completely inorganic glass insulating material composed of individual closed cells in a homogeneous multi-cellular mass is said to prevent the passage of moisture and moisture vapor, thus retaining its initial thermal conductivity for the full life of the structure, and to be noncombustible, rot-proof and warp-proof.

An illustrated bulletin containing specifications for the use of PC Foamglas to insulate concrete floors on ground and foundation walls, masonry walls and roofs may be obtained from Pittsburgh Corning Corp., 307 Fourth Ave., Pittsburgh 22, Pa.

Supplemental devices for testing machines

A 12-page bulletin describes grips, specimen holders and compression plates related primarily to transferring tension or compression load to the specimen; auxiliary testing equipment, such as subpresses and flexure tools designed to widen the range of tests; testing machine accessories, such as load maintainers and ram pacers which improve testing machine performance and conveniences not essential in testing but useful in any testing laboratory.

Bulletin 261-A is available from the Eddystone Division, The Baldwin Locomotive Works, Philadelphia 42, Pa.

Steel street forms

A new 28-page booklet (Bulletin No. 2259) on steel street forms has been issued by the Blaw-Knox Div. of Blaw-Knox Co., P. O. Box No. 2, Blawnox, Pa.

Excellent illustrations permit quick selection of paving forms for the construction of any type of

concrete curb, curb and gutter, integral curb, special curb, or sidewalk. Altogether, 16 types of forms, embodying a completely standardized and interrelated steel form system, are described and illustrated. An illustrated guide also shows how to set and strip the forms in actual use.

Bacteria-killing cement

The North American Cement Corp. has announced a new product, North American Anti-Bacterial Cement. The manufacturer claims that bacteria and fungi cannot grow on the surfaces of damp or wet concrete floors in which this cement is used. It is also said that the cement resists the formation of lactic acid and food acids which cause surface etching in floors of food processing plants. It is mixed and used like portland cement. Normal washing procedures are advised, ordinary floor soaps leaving the concrete clean without impairing the inhibitive effect on bacterial growth.

Further information can be obtained from North American Cement Corp., 41 East 42nd Street, New York 17, N. Y.

New method of installing metal sash

Fry Reglet Co., Division of Watts Electric and Mfg. Co., has announced a new method of installing metal sash that is said to eliminate all grouting and caulking and reduce sash installation time to less than five minutes. It employs a rolled metal section known as Fry Sash Reglet which is imbedded in the concrete wall or inserted in the masonry joint.

The company claims it does not require expansion bolts, clips, angles, wedges or bracing wires that normally must be used to install metal sash and permits the building contractor to put up the walls without having sash on hand.

Descriptive literature is available upon request to the Fry Reglet Co., Division of Watts Electric and Mfg. Co., Birmingham, Mich.

SYNOPSES of recent ACI Papers and Reports

[Institute papers of this JOURNAL Volume 21 are currently available at prices indicated. Please order by title and title number.]

RECOMMENDED PRACTICE FOR THE APPLICATION OF PORTLAND CEMENT PAINT TO CONCRETE SURFACES (ACI 616-49) 46-1

Price 50 cents (in special covers).

REPORT of COMMITTEE 616—Sept. 1949, pp. 1-16 (V. 46)

Supersedes 38-30 and 45-18.

This ACI standard establishes recommended practices for appropriate usage, age of concrete, preparation of surface, and the preparation, application and curing of portland cement paint. Three appendixes discuss composition, manufacture and storage, and general characteristics and factors affecting durability.

AN ULTRASONIC METHOD OF STUDYING DETERIORATION AND CRACKING IN CONCRETE STRUCTURES.....46-2

Price 35 cents.

J. R. LESLIE and W. J. CHEESMAN—Sept. 1949, pp. 17-36 (V. 46)

A new method and apparatus for field and laboratory testing of concrete is described. The apparatus called the "Soniscope" was originally designed to detect internal cracks in concrete. It develops pulses of ultrasonic sound in the material and measures the velocity of their transmission through it. This pulse velocity has the unique advantage of being independent of the size or shape of the body under test. Measurements can be made with equal facility in mass concrete, slabs or laboratory specimens.

The existence and extent of internal cracks and the depth of visible surface cracks can be determined by the use of this apparatus.

The velocity has been found, by experiment, to be a reliable measure of the condition of the concrete and is particularly useful in deterioration studies. The dynamic modulus can be calculated from this velocity, and values so obtained are found to agree closely with the results of tests using established methods.

MANUFACTURE OF REINFORCED FOAM CONCRETE ROOF SLABS ...46-3

Price 35 cents.

I. T. KOUDRIASHOFF—Sept. 1949, pp. 37-48 (V. 46)

The Russian type of lightweight concrete described used a rosin-glue emulsion to preserve the air voids before the initial set of the cement. Shrinkage was decreased and strength increased through high pressure steam curing. The autoclave treated foam concrete used in the production of precast industrial roof slabs had a unit weight of 47 lb per cu ft and a compressive strength of over 500 psi. The lightweight slabs, used in a load carrying capacity and as insulation, reduced construction time by 50 percent and costs by as much as 20 percent. Test data on roof slabs and production procedures are also described.

SUGGESTIONS ON CONCRETE FLOOR CONSTRUCTION 46-4

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ERNST GRUENWALD—Sept. 1949, pp. 49-56 (V. 46)

The relationship between good concrete floors and the proper selection of cement and aggregates is discussed. Data are cited to emphasize the advantage of coarse-aggregate mixes over cement-sand topping for concrete floors.

USE OF AIR-ENTRAINING CONCRETE IN CANAL LINING 46-5

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JOSEPH J. WADDELL—Sept. 1949, pp. 57-64 (V. 46)

This paper presents a discussion based on field observations of the use of air entrainment in canal lining concrete. The Bureau of Reclamation made studies of air-entraining agents for use in the irrigation canal lining for the Friant-Kern Canal on the Bureau's Central Valley Project in California. Results to date indicate that appreciable benefits accrue when an air-entraining agent is used in concrete which is placed and compacted by means of a mechanical slip-form. Care is necessary in adjusting concrete mixes to incorporate entrained air because of the sensitivity to mix changes of concrete for slip-form placement.

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DISCUSSION

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Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces (ACI 616-49)—Report of Committee 616

An Ultrasonic Method of Studying Deterioration and Cracking in Concrete Structures—J. R. Leslie and W. J. Cheesman

Manufacture of Reinforced Foam Concrete Roof Slabs—I. T. Koudriashoff

Suggestions on Concrete Floor Construction—Ernst Gruenwald

Use of Air-Entraining Concrete in Canal Lining—Joseph J. Waddell

Pozzolanic cements have been used since Roman times. The U. S. Bureau of Reclamation, using modern techniques, has adapted this age-old material to today's structures.

The Use of Portland-Pozzolan Cement by the Bureau of Reclamation*

By ROBERT F. BLANKS†

SYNOPSIS

The Bureau of Reclamation has made extensive studies of pozzolanic materials, and portland-pozzolan cements are now being used in many of the major structures built by the Bureau. The properties of portland-pozzolan cement that are used advantageously in the production of mass concrete are described.

INTRODUCTION

Portland-pozzolan cements are now being used in a number of major structures by the Bureau of Reclamation to combat the deterioration of concrete due to alkali-aggregate reaction and to obtain other desired properties in the concrete. In connection with this work extensive studies of pozzolanic materials have been made to achieve a better understanding of their characteristics. A pozzolan is considered as any siliceous material, natural or artificial, processed or unprocessed, which in the presence of lime and water develops cementitious properties.

The use of pozzolanic cements is not new; Fig. 1 is a photograph of a section of an old Roman aqueduct built along the Rhine River 2000 years ago. The cement used in this concrete was a volcanic pozzolan and crudely burned lime. Perhaps engineers have been remiss in not recognizing its advantages, when combined with portland cement, long ago.

Until the recent discovery that pozzolans inhibit or reduce expansion due to alkali-aggregate reaction the only remedial measure known was to limit, as low as practicable, the alkali content of the cement. This practical limit has been 0.6 percent—insufficient protection against excessive expansion where highly reactive aggregates must be used.

*Adapted from a paper presented at the spring meeting of the Portland Cement Assn., New York, May 11, 1948. Revised manuscript received by the Institute June 13, 1949. Title No. 46-6 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 21, No. 2, Oct. 1949, *Proceedings* V. 46. Separate prints are available at 35 cents each. **Discussion** (copies in **triplicate**) should reach the Institute not later than Feb. 1, 1950. Address 7400 Second Boulevard, Detroit 2, Mich.

†Member American Concrete Institute, Chief, Research and Geology Division, U. S. Bureau of Reclamation, Denver, Colo.

Fig. 1—Section of old Roman aqueduct built along the Rhine River 2000 years ago

Photo courtesy of Smithsonian Institute

The Bureau of Reclamation is now using both methods as safeguards in the concrete presently being placed in Davis Dam; that is, use of a low-alkali cement and the addition of a pozzolanic material (calcined shale) at the mixer. The specifications for Hungry Horse Dam in Montana require the use of fly ash, or an equally suitable pozzolan, in its 3,500,000 cu yd of concrete.

Pozzolan cements also are known to be effective in producing concrete resistant to the corrosive action of alkali soils and sea water. There is growing evidence that portland-pozzolan cement is the answer to many concrete durability problems, and consequently there is a definite trend toward greater and more widespread demand for pozzolanic types of cement. It is also indicated that if and when effective portland-pozzolan cements can be obtained generally, a single type of cement will meet the requirements for all uses.

Some of the recognized types of pozzolanic materials are:

1. Clays and shales (Must be calcined to activate): (a) Kaolinite type; (b) Montmorillonite type.
2. Opaline materials (Calcination may or may not be required): (a) Diatomaceous earth; (b) Opaline cherts and shales.
3. Volcanic tuffs and pumicites: (a) Rhyolithic types; (b) Andesitic types; (c) Phonolitic types.
4. Industrial byproducts: (a) Blast furnace slag; (b) Fly ash; (c) Silica fume.

PREVIOUS USE OF POZZOLAN BY BUREAU OF RECLAMATION

Investigation of pozzolans for Grand Coulee Dam

The proposed construction of Grand Coulee Dam on the Columbia River led to consideration of the advisability of using a portland-pozzolan blend. The locality abounds in deposits of diatomaceous earth, volcanic ash and other materials which might provide good pozzolan and so reduce the amount of cement needed. Accordingly, about 200 possible sources were investigated, resulting finally in the selection of a score of

acceptable materials. These were thoroughly studied in large-scale laboratory tests of 18 x 36-in. specimens containing cobble aggregate with 1 barrel of blended cement per cu yd. A pozzolan was not used in Grand Coulee Dam concrete, however, when low-heat cement was found to be available in sufficient quantity and at rates guaranteeing the completion of the structure on schedule.

Use of Fresno pumicite at Friant Dam

The Grand Coulee Dam pozzolan investigations, nevertheless, provided background information for the subsequent use of Fresno pumicite in the concrete of Friant Dam. Fresno pumicite, found in a naturally fine state immediately upstream from Friant damsite, was one of the pozzolans studied extensively. It was excavated from an open pit, after stripping the overburden, and batched at the mixer as a separate concrete ingredient. Since it was dry, unconsolidated, and extremely fine (98 percent passing the No. 325 screen) no processing was required.

Pumicite at Altus Dam

The successful employment of Fresno pumicite at Friant Dam led to further use of similar naturally fine pumicite (although somewhat coarser than Fresno) in Altus Dam in Oklahoma. A deposit of unconsolidated pumicite, with little overburden, was located within 45 miles of the dam site. It was batched as at Friant Dam as a separate item, using 35 percent by weight of the cement, the portland cement content of the mix being 0.65 barrel per cu yd. This structure has a masonry facing and no joints. Only two real cracks formed and these were a result of thermal shrinkage of the concrete. Artificial cooling was not used in this structure because the lifts were shallow and were planned to be maintained at 18 in. with placement during cool weather. However, because of construction difficulties, the depth of lift was increased to 20 in., and the concrete was placed during hot summer months at a faster rate than anticipated. Therefore, there was less dissipation of heat and higher temperature rise in this structure than was expected.

USEFUL PROPERTIES OF PORTLAND-POZZOLAN CEMENT IN MASS CONCRETE

Heat of hydration and volume change

Certain limitations of concrete must be recognized so that structures made from it may function properly. Its most objectionable characteristic is volume change. Since it expands on heating and contracts on cooling, it is prone to crack while undergoing temperature changes. Large quantities of heat are generated when the cement hydrates resulting in large temperature rise in rapidly built massive structures. Release of this heat, during the later cooling period, causes the concrete to crack unless precautions are taken. The accepted practice is to cast

the concrete in blocks with vertical joints between them, each block being restricted to such a size that on cooling it can shrink without cracking. In addition to this precaution, the temperature rise and subsequent volume change can be minimized by: (1) using a low-heat cement coupled with cooling systems to remove the heat; (2) using a low-cement content or lean mixes so that less heat is generated; (3) placing the concrete slowly in shallow lifts so that the heat generated during setting may be released to the atmosphere; (4) use of portland-pozzolan cement, with less heat generation than straight portland cement.

Portland-pozzolan cement has heat generation characteristics similar to low-heat cement, as may be seen from an inspection of Fig. 2. Not only does it produce lower ultimate heat than either standard or modified types, but it also liberates heat at more favorable rates, so that heat may be extracted as fast as generated.

Tensile strength

All investigators of pozzolanic cements agree that a portland-pozzolan cement has greater tensile strength than portland. Table 1 gives average results secured in the Bureau of Reclamation laboratories on Types I, II, and IV cements, together with various blended cements made with these portland cements as the base. Each figure represents the average value of 10 to 20 individual portland cements or portland-pozzolan blends. All types of pozzolans are represented, including pumicites, diatomaceous shales and earths, volcanic ashes, silts, raw clays, and burned clays. The greater tensile strength of portland-pozzolan cement over straight portland cement, as far as water-cured specimens are concerned, is readily apparent. Briquettes cured in sealed metal containers do not show as large an increase in tensile strength over portland cement. It is interesting to note the high tensile strength achieved with blends containing as much as 35 percent pozzolan by volume.

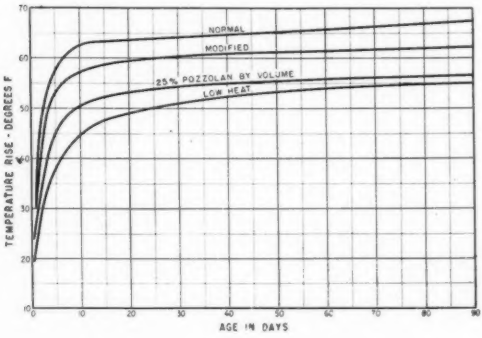

Fig. 2—Typical temperature rise with various types of cement. Grand Coulee Dam aggregate. Cement content—one bbl per cu yd

TABLE 1—AVERAGE STRENGTH—PORTLAND AND PORTLAND-POZZOLAN BLEND GRADED OTTAWA SAND MORTAR

Cement-pozzolan replacement by absolute volume	Briquette tensile strength, psi							
	Water-cured				Sealed-cured			
	7-day	28-day	1-yr	5-yr	7-day	28-day	1-yr	5-yr
Type I	400	540	530	420	420	420	520	490
−30 percent pozz. replacement	270	440	650	530	370	520	630	570
Type II	340	540	510	520	410	470	500	530
−15 percent pozz. replacement	320	480	610	560	400	470	610	530
−25 percent pozz. replacement	270	460	580	530	380	470	590	550
−30 percent pozz. replacement	240	490	650	620	360	500	590	600
−35 percent pozz. replacement	240	400	590	510	380	490	580	530
Type IV	200	440	570	470	390	470	470	450
−25 percent pozz. replacement	150	360	730	660	320	530	620	630

Compressive strength

Compressive strength values on 6 x 12-in. and 18 x 36-in. cylinders are shown in Table 2 for the same cements listed in Table 1. From a study of these data it is apparent that pozzolans do not contribute to compressive strength in the same degree that they contribute to tensile strength. Nevertheless, satisfactory compressive strengths can be achieved by using blends of portland and pozzolan even though those strengths may not equal those of straight portland cement.

The contribution of Fresno pumicite to strength is portrayed graphically in Fig. 3. These tests were made on 6 x 12-in. cylinders wet-screened from mass concrete containing cobbles. The portland cement used was low-heat cement. This chart indicates that the effectiveness

TABLE 2—AVERAGE STRENGTH—PORTLAND AND PORTLAND-POZZOLAN BLENDS, GRAND COULEE DAM AGGREGATE

Cement-pozzolan replacement by absolute volume	Compressive strength, psi											
	6 x 12-in. cylinders								18 x 36-in. cylinders			
	Standard cure				Mass cure				Standard cure		Mass cure	
	7-day	28-day	90-day	1-yr	7-day	28-day	90-day	1-yr	28-day	90-day	28-day	90-day
Type I	2950	4530	5320	6460	3910	4260	4460	4810	3480	4260	3830	3820
30 percent pozz. rep.	1540	2990	4170	5500	2980	4670	4670	5000	2460	3640	3560	3960
Type II	2810	4820	6070	7040	4220	5090	5280	5550	4060	5130	4880	5200
15 percent pozz. rep.	2270	4380	5580	6330	4010	4890	4700	5120	3470	4900	4680	4870
25 percent pozz. rep.	1830	3790	5480	5690	4000	4720	4560	4830	3030	4310	4190	4380
30 percent pozz. rep.	1650	3400	5080	6240	2920	4770	4770	4960	2860	4140	4400	4470
35 percent pozz. rep.	1390	3270	4790	5680	3310	4270	4250	4390	2550	3780	3910	4230
Type IV	1270	3860	5600	7000	2960	5100	5570	5910	3250	4390	4520	4660
25 percent pozz. rep.	810	3000	5040	6640	1800	3940	4430	5230	2460	4500	4080	4180

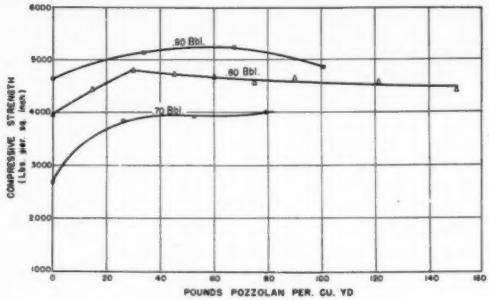

Fig. 3—Strength of mass concrete containing varying amounts of pumicite—one year age, Friant Dam

of Fresno pumicite drops off as more of it is used. Its greatest effectiveness is in the range of 40 to 60 lb per cu yd, or 15 to 20 percent by weight of the portland cement. In Friant Dam, 20 percent by weight of the portland cement was used in a mix containing 0.8 barrel of portland cement per cu yd. Pumicite also seems more effective in the leaner mixes.

Fig. 4 shows the contribution of ground calcined Phillips shale to strength when the cement in a mix is replaced by an equal weight of the pozzolan. At 90 days the shale is shown to contribute slightly more to strength than portland cement itself—up to a 15 percent replacement. Beyond this amount its effectiveness decreases.

Sulfate resistance

The superior resistance of portland-pozzolan cement to sulfate attack has been mentioned and demonstrated so often that further discussion seems unnecessary.[1,2,3] However, in support of this point Fig. 5, from Bureau of Reclamation tests, is presented showing the length of time taken for neat cement slabs to fail in a 10 percent sodium-sulfate solution (Merriman test). Each bar represents the average of tests on several cements of the type indicated; in the case of pozzolan blends, more than 10 different materials, including diatomaceous earths, pumicites, volcanic ash, silts, and clays were tested.

Extensibility

Mention has been made of the favorable heat-producing characteristics of portland-pozzolan cement as affecting cracking. Both low-heat and portland-pozzolan cements also inherently resist cracking, apparently because of increased plastic flow and extensibility. This has been demonstrated in tests designed to hold specimens to a constant length while undergoing a temperature cycle duplicating that found on the bottom of a 5-ft layer of mass concrete beginning from the time the concrete is freshly placed.

Six-inch diameter specimens 24 in. long, made with normal, modified, low-heat and portland-pozzolan cements, and one aggregate common

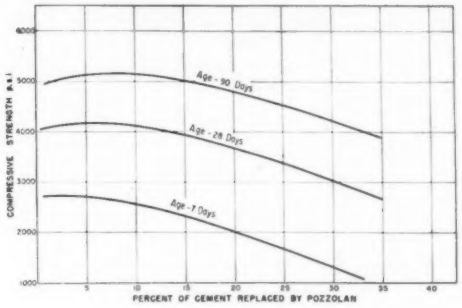

Fig. 4—The compressive strength of concrete increases slightly, then decreases as cement is replaced with an equal weight of pozzolan. Average of three series of tests—Davis Dam project

to all, were cast in hermetically sealed dead-soft copper jackets, with strain gages embedded on their longitudinal axes. They were taken through a rising and falling temperature cycle, each appropriate for the heat of hydration of the particular cement, as illustrated at the top of Fig. 6. As they tended to expand, they were held to constant length in a spring compression yoke (Fig. 7). Then, as they cooled and the compressive stress was relieved, they were transferred to spring tension frames and held to constant length as they underwent tensile stress. Before reaching the initial starting temperature, the specimens made

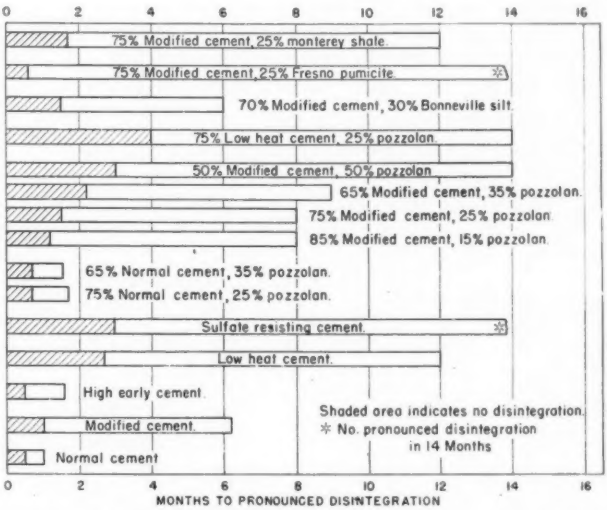
75% Modified cement, 25% monterey shale.
75% Modified cement, 25% Fresno pumicite.
70% Modified cement, 30% Bonneville silt.
75% Low heat cement, 25% pozzolan.
50% Modified cement, 50% pozzolan.
65% Modified cement, 35% pozzolan.
75% Modified cement, 25% pozzolan.
85% Modified cement, 15% pozzolan.
65% Normal cement, 35% pozzolan.
75% Normal cement, 25% pozzolan.
Sulfate resisting cement.
Low heat cement.
High early cement.
Modified cement.
Normal cement
Shaded area indicates no disintegration.
* No. pronounced disintegration in 14 Months
MONTHS TO PRONOUNCED DISINTEGRATION

Fig. 5—Resistance of portland and portland-pozzolan cements in 10 percent Na_2SO_4, Merriman's method

with normal modified cements failed. The specimens made with low-heat and portland-pozzolan cement were held at their initial temperature for a period and then slowly cooled while held to their original lengths. The lower part of Fig. 6 shows that they resisted stresses of 300 and 270 psi before failing, blended cement exhibiting much greater plastic flow,

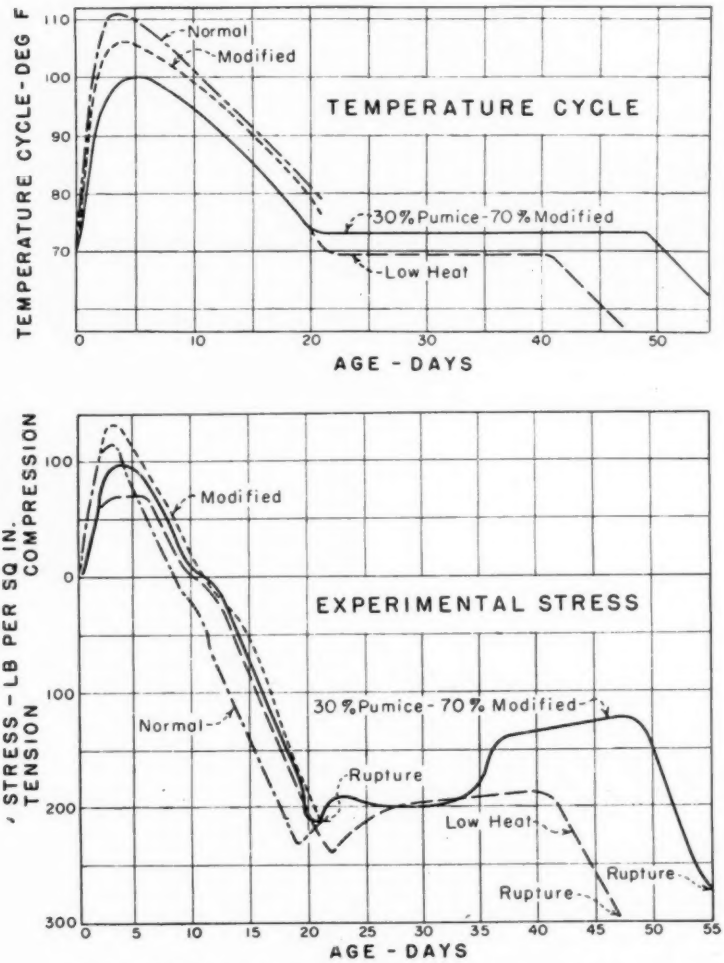

Fig. 6—Extensibility of mass cured concrete with four types of cement

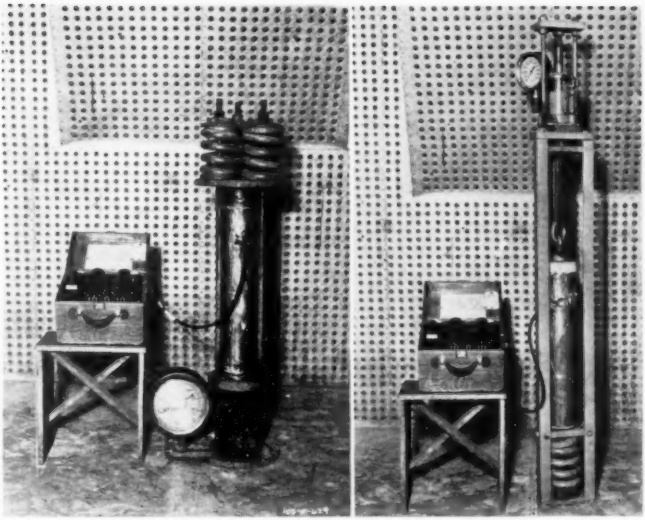

Fig. 7—Spring compression yoke (left) and spring tension frame (right) for measuring extensibility of concrete

while being held at the initial temperature. This test offers some explanation for the fewer cracks found in structures made from low-heat and portland-pozzolan cements.

Although many investigators have found that concrete made with portland-pozzolan cement shrinks more than concrete made with portland cement, the difference is not great and appears to be balanced, as far as cracking is concerned, by the greater extensibility. Fig. 8 shows the average volume changes of several portland and portland-pozzolan cements, as determined by Bureau of Reclamation tests. Initial length measurements were taken at two-days' age and temperature corrections made from thermal coefficients established from the bars left sealed after 90-days' age. There is no great difference in drying shrinkage between the portland and blended concrete. During adiabatic curing (first 28 days) portland-pozzolan cements show some negative volume change as compared to slight positive change for the portland cements.

Leaching of portland-pozzolan cements

The ability of pozzolanic materials to reduce the rate at which soluble compounds are leached from concrete is generally accepted. One investigator, R. Zollinger,[4] compared portland cements with and without siliceous admixtures. He concluded that there is a considerable varia-

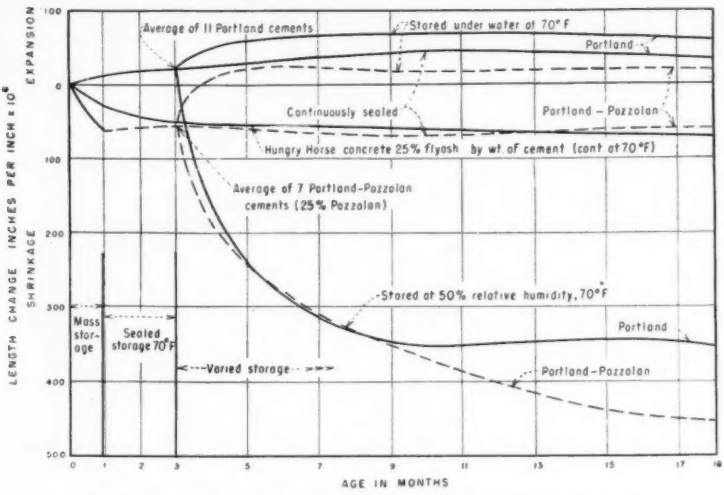

Fig. 8—Length change of 4 x 4 x 40-in. concrete bars (mass cured)

tion in volume change for different materials absorbing equal amount of lime, and suggested that materials be rated on this property. The amount of swell is related to reduced leaching because of decreased permeability, in addition to the chemical combination with the lime.

Some data on reduced leaching have been given by P. S. Hakanson,[5] who notes that pozzolanic cements are used in Sweden because of their resistance to soft waters. His tests were made on crushed samples, so no effect of increased denseness was credited. Other investigators, principally Russian, have also reported reduced leaching.

Permeability

Considering the statements made concerning leaching, it can be deduced easily that concrete made with portland-pozzolan cement will show greater impermeability in hydraulic structures, with the passage of time, than will concrete made with portland cement. The watertightness of structures made with blended cement, considering even the sand-cement of questionable pozzolanic activity used in Arrowrock Dam and Elephant Butte Dam, attest to this.

Durability

Many accelerated freezing and thawing tests have been made in the Bureau laboratories on concretes containing portland-pozzolan cements. In general, the portland-pozzolan cements are not found to give durability equal to that of portland cement. In a few instances equal dura-

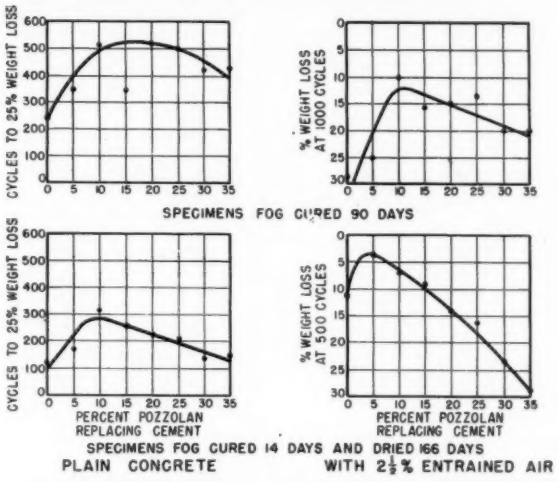
CYCLES TO 25% WEIGHT LOSS
% WEIGHT LOSS AT 1000 CYCLES
SPECIMENS FOG CURED 90 DAYS
CYCLES TO 25% WEIGHT LOSS
% WEIGHT LOSS AT 500 CYCLES
PERCENT POZZOLAN REPLACING CEMENT
PERCENT POZZOLAN REPLACING CEMENT
SPECIMENS FOG CURED 14 DAYS AND DRIED 166 DAYS
PLAIN CONCRETE
WITH 2½% ENTRAINED AIR

Fig. 9—Resistance to freezing and thawing—Davis Dam concrete

bility is achieved, provided the proportion of pozzolan in the blend is not too great. Phillips shale is one of the few pozzolans which has shown increased durability in blend with portland cement. Fig. 9 portrays this graphically. Since air-entraining concrete is many times more durable than plain concrete, the tests shown on the two right-hand diagrams have not yet been completed. Durability in these diagrams is therefore expressed in terms of weight loss found at a given number of cycles; whereas the scale in the two left-hand diagrams indicates the cycles at which failure occurred. These charts show that blended cements made from Phillips shale have better durability than the portland cement used in the blend, provided the amount of calcined shale is between 10 and 20 percent by weight of the portland constituent.

POZZOLANS FOR COMBATTING EXPANSIVE REACTIONS

On the lower Colorado River a number of structures are expanding at an alarming rate due to alkali-aggregate reaction. These cases have been sufficiently publicized in the technical journals[6,7] and need not be further described here. However, the Bureau of Reclamation is now constructing a large dam, Davis Dam, in this vicinity, and it first was felt that cements low in alkali would be sufficient to counteract this reaction. Later tests showed that such was not the case and that, even though the alkalies in the cement used were below 0.6 percent, expansion might still result. The Bureau then began to search for some material

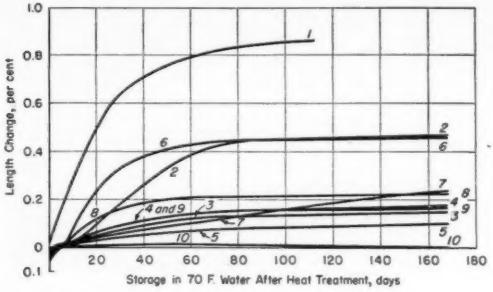

Fig. 10—Expansion of concrete made with reactive aggregate

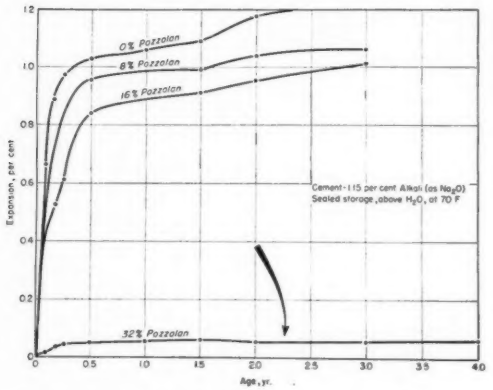

Fig. 11—Effect of sealed storage on expansion by substituting pozzolan for cement

which would help prevent expansion in this concrete. Pozzolans had given indications of counteracting this reaction and extensive tests showed that Monterey shale available near the job was very effective in counteracting alkali-aggregate expansion.

A. D. Conrow[8] has reported results of investigations on expanding sand-gravel concrete prevalent in the Kansas-Nebraska area. He investigated several laboratory storage conditions in an effort to produce in the laboratory expansion similar to that occurring in the field. He found that by heating the bar in a water bath and a drying oven, with intermediate cooling, and final water-bath storage at 70 F an abnormal expansion was obtained which continued to increase without additional cyclic curing. A temperature of 130 F was the most effective —higher temperatures inducing less expansion.

Fig. 10 shows the expansions obtained on specimens of sand-gravel concrete subjected to such curing conditions. Curves 1 and 2 are for specimens made with portland cements containing 0.4 percent and 0.6 percent alkalies, respectively. The remaining curves represent expansions

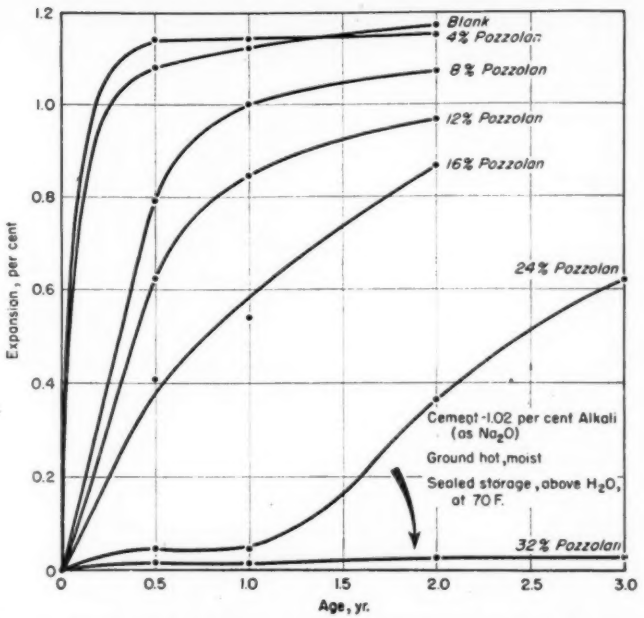

Fig. 12—Effect of sealed storage on expansion by substituting pozzolan for cement

secured with various blended cements which, except for No. 6, were much lower than the portland cement.

W. C. Hanna, has published data,[9] to four-years' age, on the use of calcined Phillips shale as an inhibitor of expansive recreation. These results are shown in Fig. 11 using a cement of 1.15 percent alkali (as Na_2O) and in Fig. 12 for a cement of 1.02 percent alkali. From these data, it is seen that 30 percent pozzolan and 70 percent cement is the proper porportion in which to blend Phillips shale with a high-alkali cement for use with reactive aggregate. In Table 3 are recorded some of the Bureau's data showing the effectiveness of pozzolanic additions to reactive combinations. All of the pozzolanic materials listed, with the exception of calcined shale (AG), successfully reduce the expansions. The calcined shale (AG) inhibited the expansion of Kimball aggregate fairly well, although not as effectively as the Davis pozzolan.

POZZOLAN FOR DAVIS DAM

With this background of data demonstrating that Phillips shale and Monterey shale are effective additives to combat expansive reaction,

TABLE 3—USE OF CERTAIN POZZOLANS REDUCES EXPANSION OF REACTIVE AGGREGATES

Aggregate (natural sands)	Pozzolan 20 percent replacement by weight	Percent expansion						
		Age in months						
		1	2	3	4	5	6	12
Boysen Dam Wyoming	None	0.019	0.033	0.071	0.099	0.100		
	Davis Dam	−0.001	−0.002	0.002	0.004	−0.001		
	Tuff (Tufa)	0.007	0.009	0.015	0.018	0.014		
Kimball Nebraska	None	0.003	0.030	0.064	0.091	0.118		
	Davis Dam	−0.006	−0.007	−0.005	−0.003	−0.001		
	Cedar Bluffs, Kan.	−0.007	−0.005	−0.003	−0.001	*0.001		
	Calcined shale (A.G.)	0.000	0.007	0.008	0.016	0.021		
Republican River Nebraska	None	0.002	0.013	0.024	0.031	0.038		
	Davis Dam	−0.003	−0.004	−0.002	0.001	−0.001		
	Cedar Bluffs, Kan.	−0.006	−0.004	−0.002	0.000	−0.001		
	Calcined shale (A.G.)	−0.002	0.012	0.027	0.032	0.035		
Davis Dam Arizona	None	0.010	0.018	0.021	0.028	0.040	0.050	0.091
	Davis Dam	0.001	0.002	0.000	−0.001	0.000	−0.001	0.003
Coolidge Dam Arizona	None	−0.001	0.011	0.018	0.064	0.110	0.171	
	Davis Dam	−0.009	−0.009	−0.009	−0.002	0.000	−0.001	
Stewart Mountain Dam Arizona	None	0.010	0.022	0.027	0.041	0.067		
	Davis Dam	0.000	0.000	−0.001	−0.001	0.001		
	Calcined siliceous material (SOU.S)	0.000	0.002	0.002	0.001	0.003		

*Popouts and leaching indicate reaction in this combination.

the Bureau determined to use this material in Davis Dam. Accordingly, specifications were written and an advertisement issued for "Calcined Reactive Siliceous Material," which attracted considerable attention. Besides defining and circumscribing the desired material within chemical limits, these specifications included three tests for activity: (a) strength test in combination with lime; (b) reduction in the alkalinity of a caustic solution in which the material is placed; and (c) reduction in expansive reaction of a mortar bar made from crushed Pyrex glass.

Lime-pozzolan strength test

The strength test in combination with lime was included because it has long been used as a test for pozzolanic activity, being one of the performance acceptance tests in the specifications for portland-pozzolan cement for Bonneville Dam. The Davis Dam specifications required that the lime, sand, water, and pozzolan mixture have a compressive strength of not less than 600 psi in 2 x 4-in. cylinders stored in a sealed container for 1 day at 70 F and 6 days at 130 F.

Pyrex glass expansion test

Test for reduction in expansive reaction is made on a mortar bar containing crushed Pyrex glass as aggregate and a cement of high-alkali content. Crushed Pyrex glass, all of which is retained on a 100-mesh sieve, will, when combined with a high-alkali cement and cured at 100 F in sealed containers in the presence of water, cause rapid and destructive expansion in the hardened mortar. Reactive siliceous material, when

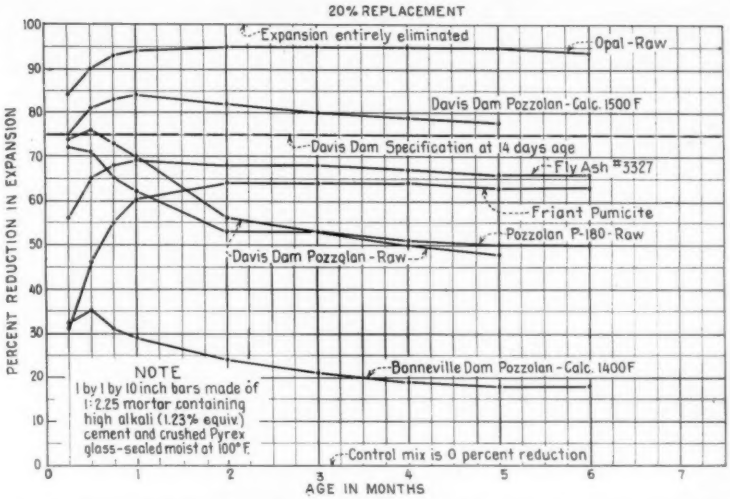

Fig. 13—Reduction in expansion due to alkali-aggregate reaction by replacement of 20 percent of cement with various pozzolans

added to such a mixture will reduce the expansion and the specifications required that a replacement of 20 percent of the high-alkali cement with prospective siliceous material reduce the expansion (as compared to a mixture with no siliceous material) by 75 percent at 14 days. Pyrex glass was specified because of its uniform composition; the glass fines were excluded because they are effective themselves in reducing expansion. Fig. 13 shows some of the results achieved in this test with various materials, expressed as the percent reduction in expansion of bars made without pozzolan. Two of the test materials, raw opal and the Davis Dam pozzolan calcined at 1500 F, meet the specification requirements. Notice that the Davis Dam pozzolan is very ineffective in the raw state. Calcined Monterey shale and raw opal are effective materials in this test; fly ash is fairly so. Since 20 percent of the cement is removed when testing the prospective material, some of the reduction in expansion may be ascribed to the lower alkali content of the mix. This effect may be partially evaluated by examination of Fig. 14, which data were secured on Pyrex glass bars with various amounts of the high-alkali cement. By comparing the curve for Bonneville Dam pozzolan in Fig. 13 with the effect of reduced cement in Fig. 14, one would conclude that the Bonneville Dam pozzolan was entirely ineffectual as an inhibitor of expansive reaction.

Test for reduction in alkalinity and silica release

The chemical test for reactivity of pozzolans is performed as follows: 12.5 grams of the prepared pozzolanic material are mixed with 25.0 ml of 1 N *NaOH* solution and maintained at 80 C for 24 hours. The solution then is filtered from the solid substance and is analyzed for dissolved silica and the reduction in the alkalinity of the solution is determined by titration. The reduction in alkalinity by the shale specified for use at Davis Dam was found to be a reliable index of its activity. Consequently, a reduction in alkalinity of 40 percent was specified for acceptable materials, but no limits were placed upon silica release. However, for estimation of activity of pozzolans in general, both reduction in alkalinity and silica release must be determined.

The results of the three activity tests on 18 miscellaneous materials are compiled in Table 4. It is evident that the compressive strength of the lime mortar is only a vague clue to the effectiveness of the pozzolan in controlling alkali-aggregate reaction. Materials which reduce the mortar expansion more than 75 percent at 14 days (the specified lower limit for materials accepted for use at Davis Dam) in each case will also meet the required 600 psi compressive strength in the lime-mortar test. However, several materials developing proper mortar strength do not effectively control alkali-aggregate reaction. While the effective admixtures are pozzolans, all pozzolans do not suitably control alkali-aggregate reaction.

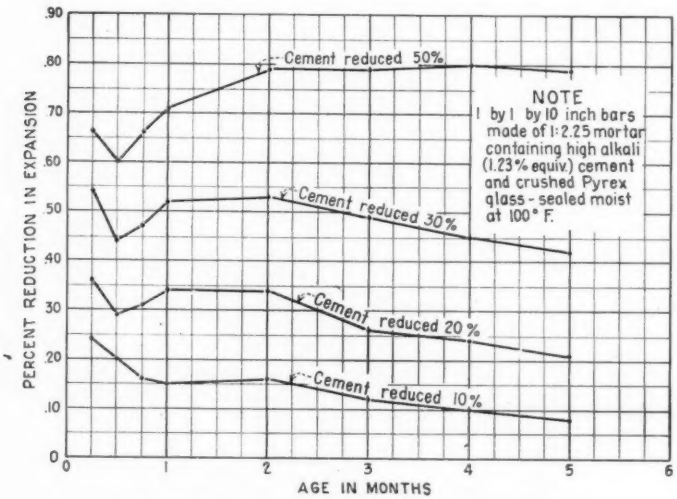

Fig. 14—Expansion is reduced by lowering cement content

TABLE 4—MATERIALS TESTED UNDER DAVIS DAM SPECIFICATIONS

Test material	Lime mortar test compressive strength, psi	Chemical test		Reduction of Pyrex glass mortar expansion	
		Reduction in alkalinity, percent	Silica dissolved, percent	14 day*	2 month*
1 Davis Dam pozzolan (Puente SH), Calif., raw	1790	38	8.6	76	57
2 Davis Dam pozzolan (Puente SH), Calif., calcined	1550	51	5.3	81	82
3 Fly ash, Ill.	1422	42	0.48	65	68
4 Bonneville silt, Calif., calcined 1400 F	1415	53	1.7	35	24
5 Tuff (Tufa), Calif., raw	1216	39	5.0	71	53
6 Tuff (Tufa), Calif., calcined 1400 F	630	31	5.6	78	71
7 Pozzolan (A.G.), Kan., calcined 1400 F.	1065	20	0.29	16	31
8 Tuff, Calif., raw	980	40	6.2	78	80
9 Tuff, Calif., calcined	670	24	5.5	61	74
10 Diatomaceous earth, Calif., raw	955	—	—	91†	81†
11 Diatomaceous earth, Calif., calcined 1500 F.	774	26†	33.6†	94†	87†
12 Opal, Wash., pulverized, raw	900	22	12.9	90	95
13 Pyrex glass, pulverized, raw	770	23	8.2	92	87
14 Pumicite, Calif., raw	690	18	2.2	70	82
15 Pumicite, Calif., calcined	650	19	2.1	63	77
16 Basaltic tuff, Ore., calcined	560	24	1.8	44	63
17 Boiler slag, Ill.	515	14	0.11	44	56
18 Pozzolan, Calif.	230	17	2.2	27	38

*20 percent, by weight, of cement replaced by test material.
†10 percent replacement, by weight; 7½ grams in chemical test.

The effective pozzolans so far discovered include the calcined siliceous (opaline) shale, certain pumicites and tuffs, opal, Pyrex glass, and diatomaceous earth. Some materials will meet the required reduction in mortar expansion at 14 days, but with passing time mortars containing them continue to expand. For example, a tuff (tufa) from California reduces the expansion 78 percent at 14 days, 71 percent at 2 months, and only 67 percent at 6 months. The pozzolan (AG), Kansas, calcined at 1400 F, developed 1065 psi compressive strength in lime mortar, yet reduced the alkalinity only 20 percent, released only 0.29 percent silica, and reduced the mortar expansion only 16 percent at 14 days. This same material did not significantly reduce expansion of mortar containing aggregate from the Republican River.

As was mentioned previously, the effectiveness of all types of pozzolanic materials cannot be evaluated by measurement of reduction in alkalinity of a caustic solution, although the effectiveness of calcined siliceous shales from the Upper Pliocene Strata of southern California can be determined satisfactorily in this way. However, experience demonstrates that all of the tested materials which reduce the mortar expansion 75 percent or more at 2 weeks at 20 percent replacement reduce the alkalinity greatly or release considerable silica. Specifically, as illustrated in Fig. 15, effective materials are represented by data points falling above and to the right of a line whose locus is derived empirically as:

$$R + 2/3S = 630$$

where R = alkalinity reduction in millimoles per liter; and S = silica dissolved in the $NaOH$ solution in millimoles per liter. However, two materials represented by data points falling just to the right and above the line are not wholly effective. All of the materials falling well above or well to the right of the line are satisfactory controllers of cement-aggregate reaction in concrete or mortar. However, in view of the two anomalous determinations, further research now in progress was undertaken, and the results to date indicate that a completely diagnostic chemical technique can be developed.

Fly ash to be used in Hungry Horse Dam

The very fine flue dust precipitated from the stacks of steam power plants burning powdered coal had been found to possess pozzolanic properties. This has been demonstrated by R. E. Davis, et al, in an extensive series of investigations.[10] McMillan and Powers also studied this material along with many other concrete admixtures.[11] Some mention of it has been made in this paper and in Table 4 and Fig. 13.

The specifications for Hungry Horse Dam, now under construction on the Flathead River in western Montana, required the use of pozzolanic material, specifically fly ash, but permitting any other equal pozzolan. The contractor has elected to use fly ash produced in the Chicago area. The merits of fly ash and the properties of concrete containing fly ash, with particular reference to Hungry Horse Dam concrete, will be discussed in a subsequent paper.

CONCLUDING COMMENTS

From the summary of evidence presented, it can only be concluded that appropriate combinations of portland cement and suitable pozzolanic materials impart to concrete many of the qualities sought. This conclusion applies not only to mass concrete but to other types of construction. At the same time it must be admitted that there are many unknown or incompletely understood factors.

Details of the changes in kaolinite clays during calcination are not known. Optimum activity with lime is induced by calcination at 1300-1475 F and decreases at higher temperature.

Information also is limited on this characteristic of montmorillonite type clays although a change in crystalline structures is known to occur during calcination. These materials are highly absorptive if calcined at 1200-1400 F. In this range the crystal lattice is collapsed probably due to loss of water and possibly some cations such as Ca^{++}. When immersed in an alkaline solution or admixed with hydrating portland cement, the alkalies apparently enter the crystal lattice and are held there more or less permanently.

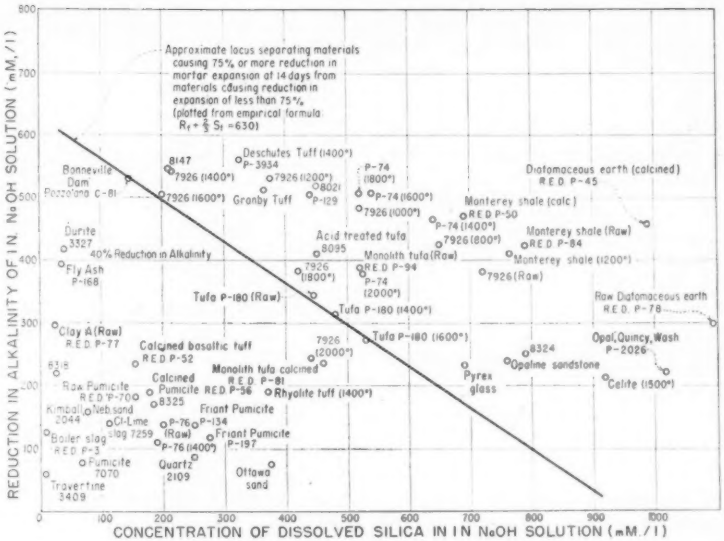

Fig. 15—Results of chemical test with *NaOH* solution

Uncalcined clays do not permanently hold the alkalies; and clays calcined at 2000 F or more are virtually inert because their crystal structures are destroyed. The effective clays are characterized in the chemical test with *NaOH* solution by a very large reduction in alkalinity of the solution. This is the principle justifying the required 40 percent reduction in alkalinity for the material purchased for use at Davis Dam.

The siliceous materials which control alkali-aggregate reaction do so by holding the alkalies in alkali silica gels produced by attack of the alkaline solutions in the cement paste upon the particles of pozzolan. These substances are indicated in the chemical test by large release of silica into the *NaOH* solution; the alkalinity reduction typically is moderate or small. The effectiveness of the natural siliceous materials is impaired by calcination to 2000 F although no recrystallization occurs.

The physical-chemical processes by which pozzolans and lime combine to form cementitious compounds is unknown. If alumina and silica are present then it would appear that calcium aluminates, and silicates or alumino-silicates would be formed. Experience has shown that the quality of at least some clay-type pozzolans is improved as the content of Al_2O_3 increases; moreover, calcined bauxite is a satisfactory pozzolan for ordinary uses. It seems, therefore, that alumina plays an essential role in the reaction of lime with the pozzolan.

The highly siliceous materials such as opal and acid volcanic glasses undoubtedly yield calcium silicates upon reaction with lime, although the 10-15 percent of Al_2O_3 in the glasses may yield aluminates or aluminosilicates of calcium. The cementation must occur by welding of adjacent bodies of gel and interlocking of the matrix of crystals.

In general, the chemical and activity tests of pozzolans indicate that the artificial types, such as granulated blast furnace slag and fly ash, are comparatively ineffective in reducing alkali-aggregate expansion in concrete. However, mortar and concrete bar expansion tests show that fly ash is quite efficient in reducing such expansion, particularly at later ages.

It is known that the most reactive aggregates make excellent pozzolans when finely ground. The explanation is not known. Diatomaceous materials are among the most efficient pozzolans but they require excessive amount of water when used in concrete and result in high volume changes. There is reason to believe that such characteristics can be corrected by proper treatment (fine grinding and calcination) and the use of chemicals (wetting agents, etc.).

The obvious answer to these unsolved problems is research. The importance of intensifying and broadening our research activities in the field of cementitious materials cannot be overemphasized.

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Cavitation forces will pit steel and the most durable concrete. A laboratory apparatus has been developed for comparing

Resistance of Concrete and Protective Coatings to Forces of Cavitation*

By WALTER H. PRICE† and GEORGE B. WALLACE‡

SYNOPSIS

A machine used for producing cavitation erosion in the laboratory is described and the results of tests made to investigate the effect of mix proportions, surface treatment, and protective coatings on the resistance of concrete to cavitation are discussed. Through proper use of these, the resistance of concrete surfaces to cavitation erosion may be extended three or four times, but even the best concrete will not resist the forces of cavitation for a prolonged period. Heavy rubber coatings bonded well to the surface of the concrete have proved effective.

INTRODUCTION

Pitting of concrete due to nonuniform flow of clear water at velocities above 50 fps is common in hydraulic structures. This damage has been shown to be due to the collapse of small vapor bubbles or cavities which form in running water whenever the pressure at a point in the liquid is reduced to its vapor pressure. These cavities flow downstream with the water, and upon entering an area of higher pressure collapse with great impact. Repeated collapse of such cavities near the surface of the concrete will pit it. Pitting resulting from cavitation can be easily distinguished by its honeycombed appearance as contrasted to the smoother surfaces resulting from damage by abrasion.

The apparatus used for developing cavitation in a stream of flowing water and for comparing the resistance of concrete and protective coatings is shown in Fig. 1. Tests were made on concretes of various water-cement ratios, strengths, air contents, and upon vacuum-treated surfaces and surfaces cast against absorptive form linings. A number of types of synthetic rubber-like coatings and methods of application were

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also investigated. In order that the reader may evaluate the severity of the attack resulting from cavitation, the results of tests of concrete subjected to the impact of high-velocity water jets and to the jet of a shot-blast are included.

LABORATORY TESTS

The test specimens used were 4½ x 4¼ x 12 in. in over-all dimension, with a ⅝-in. tapered offset on two faces. An area of 3 x 10½ in. was exposed in the cavitation tests. The specimens were designed so that two sides could be tested, and they were cast with the surfaces to be exposed in a vertical position. Specimens were cast to determine the effect of water-cement ratio (strength), slump, amount of entrained air, and age on the resistance of the concrete to erosion. The water-cement ratios were varied from 0.45 to 0.70, by weight, the slumps from 1 to 5 in., the air contents from 0 to 6 percent, and the specimens were tested at 28 and 90 days. The aggregate was uniformly graded up to 1½-in. maximum size. Type II cement was used in all specimens.

Vacuum treatment, absorptive form lining, and stoning and grinding techniques were applied to some specimens which were tested at 14 and 28 days. Others were coated with Amercoat, Neoprene, Polythene, and Thiokol plastic coatings. These coatings were applied to a dry concrete surface in varying thicknesses, ranging up to 0.125 in. The Amercoat was sprayed on cold, the Neoprene brushed or troweled on cold, the Polythene applied by flame spraying, and the Thiokol applied by flame spraying and also by cold brushing. To provide a resilient protective coating mechanically locked into a concrete surface, a 1-in. thick rubber slab with protruding wedge-shaped edges was embedded in a specimen. A cold brushed coating of Neoprene and a flame-sprayed coating of Thiokol were also applied to a milled mild steel surface.

The machine used in testing the specimens (Fig. 1) was designed to form a low pressure area in the flowing water near the Venturi throat. Vapor bubbles formed in this area and were carried downstream until the pressure increase caused them to collapse. The collapse of the bubbles is extremely destructive to contiguous surfaces. The rate of destruction by this action is dependent on the resistance of the boundary material, the frequency, pressure and temperature of the bubble collapse.

The machine is so designed that two concrete specimens can be placed in the machine at one time. The area of collapse of the bubbles may be moved upstream or downstream by increasing or decreasing the differential between the upstream and downstream pressures. Through a series of trial runs it was found that the center of the collapse area could be located directly under the specimen nearest the Venturi throat when the upstream pressure was 11.55 ft of mercury (pump capacity) and

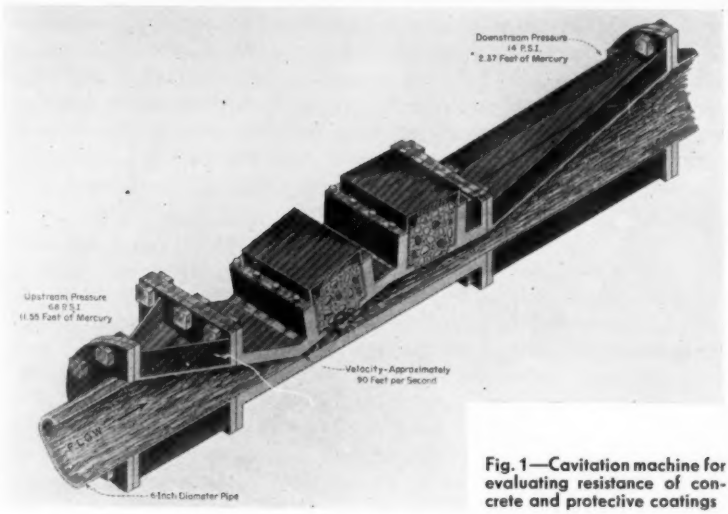


Fig. 1—Cavitation machine for evaluating resistance of concrete and protective coatings

the downstream pressure 2.37 ft of mercury. This difference in pressure produced a maximum velocity of approximately 90 fps. These pressures were chosen for the standard operating condition. Three hours was chosen as the standard exposure period.

The specimen downstream from the Venturi throat was not attacked because it was located beyond the area of collapsing bubbles, and in no case did it show signs of pitting or erosion, even in very weak concretes. This second specimen served to show that the damage was not due to the high-velocity flow of the water over the specimen. The machine was designed so that air could be introduced in the cavitation area and the effect of its introduction studied through a glass plate.

For comparative purposes, concrete was also subjected to the discharge of a 1-in. American la France nozzle located 15 in. from the surface of the specimen. Each specimen was exposed for a period of 10 days, 24 hours a day, to a clear water jet flowing at the rate of 90 fps normal to the surface of the concrete. Abrasion tests were also made by subjecting the concrete specimens to the shot-blasts of a Reumelin abrasion machine. In this test, air pressure was maintained at 80 psi, and a charge of 2000 grams of No. 50 steel grit was shot at the surface of the specimen through a $\frac{3}{16}$-in. nozzle held $4\frac{1}{2}$ in. from the surface. The 2000 grams of shot was discharged in 3 minutes.

Screws cast into the specimens served as reference points from which the depth of erosion could be measured through holes in a flat plate, as

shown in Fig. 2. From these measurements the volume of erosion was computed. This volume was checked by a volumetric displacement method which compared the volume of the specimens before and after erosion. The erosion resistance is expressed as the number of hours required to erode 1 cu in. per sq in. of surface exposed. This value is computed by assuming that the rate of erosion established during the standard time of exposure would continue until 1 cu in. of material is eroded from each sq in. of exposed surface.

DISCUSSION OF RESULTS

Fig. 3 and 4, and Table 1 show that the resistance of concrete to cavitation erosion is increased by lowering the water-cement ratio and increasing the strength of the concrete. There is a pronounced difference in the resistance of concretes of different water-cement ratios and strength, but even the best concrete was pitted during the 3-hour exposure. The test results indicate that the resistance of concretes with equal strengths to cavitation erosion is not appreciably influenced by the amount of entrained air in the concrete within the range of air contents normally used. When the water-cement ratio was held constant and the air content and strength varied, the resistance to cavitation erosion varied directly with the strength. Likewise, the stronger 90-day specimens were considerably more resistant than those exposed at 28 days. There is some indication, however, that the resistance of the concrete is influenced by the slump apart from the strength, as indicated by the results shown in Table 1.

A vacuum applied through a porous mat to the surface of fresh concrete to extract air and water resulted in an average increase in the resistance to cavitation erosion of about 300 percent over similar untreated specimens. A vacuum of 20 in. of mercury applied to the specimens for 30 minutes extracted an average of 0.052 gal. of water per

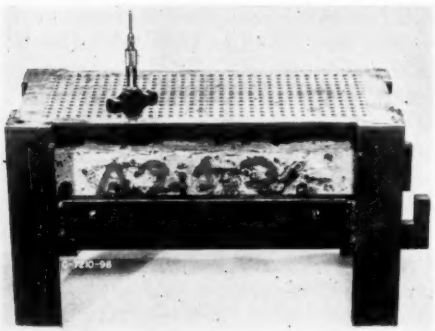


Fig. 2—Depth of erosion survey instrument

sq ft of the surface covered by the porous mat. Observations of the specimens after treatment indicated that the effect of the vacuum was not confined to the surface covered by the mat, but extended around to the adjacent sides of the specimens. However, it did not extend through the 4¼-in. thick specimen as indicated by lack of improvement in resistance of the opposite side. Fig. 5 shows the treated and nontreated specimens after cavitation exposure.

Specimens formed against Hydron or ½-in. thick rigid-type absorptive form lining and tested at 14 days showed but little increased resistance to cavitation erosion over specimens formed against wood. However, later tests of absorptive form lined specimens at 28 days were considerably more resistant to cavitation than similar specimens cast against wood. The ½-in. rigid lining was more effective than the Hydron in the 28-day tests.

Stoning a rich grout into the voids of the concrete test surface, fog curing 14 days, and then grinding the surface smooth increased the resistance to cavitation over comparable concrete specimens without surface treatment.

Although concrete was severely damaged by the forces of cavitation in the cavitation machine, comparable concrete was not damaged appreciably by clear water jets impinging against the surface at 90 fps for 10 days. This indicates that impact alone is not nearly as damaging as the rapid and frequent collapse of bubbles in flowing water.

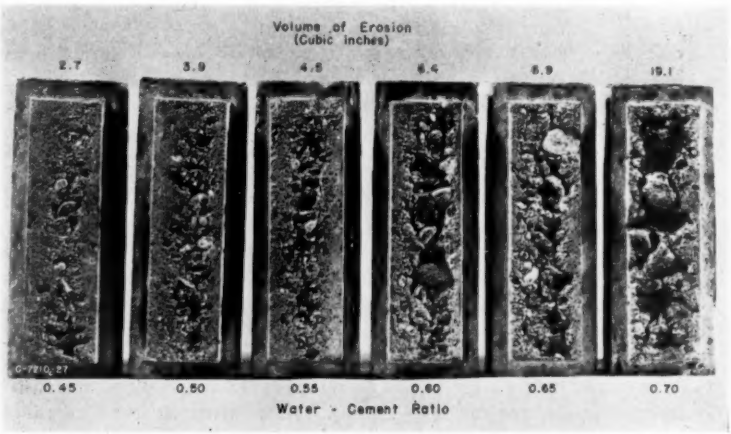


Fig. 3—Resistance of concrete to cavitation after 3 hours exposure to cavitating stream in Venturi type cavitating machine. The resistance to cavitation erosion is increased by lowering the water-cement ratio.

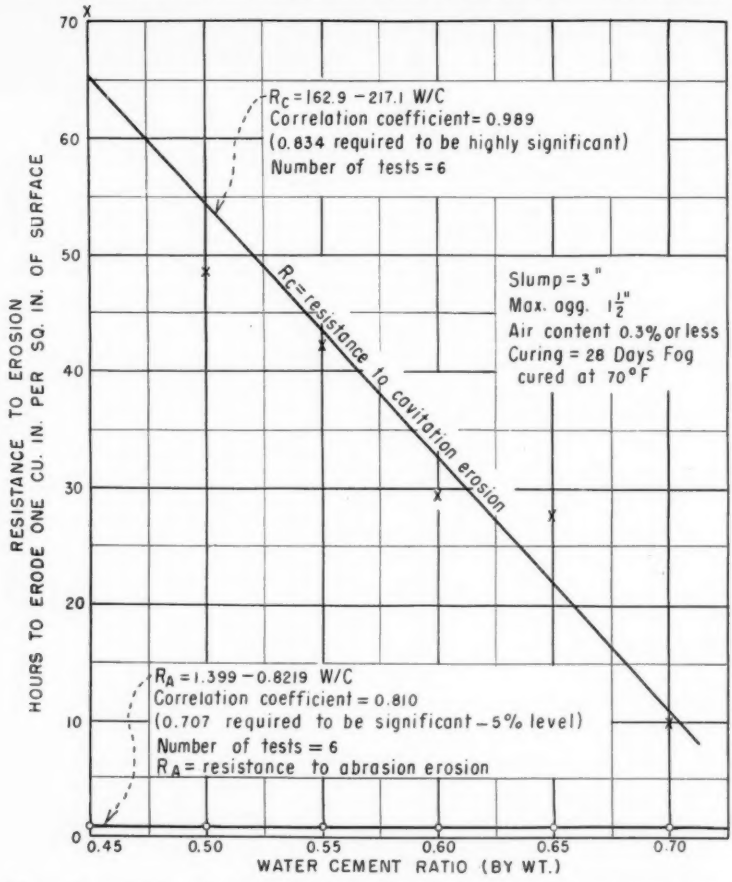


Fig. 4—The resistance of concrete to erosion varies inversely with the water-cement ratio.

The introduction of air in the flowing water near the cavitation area had a pronounced effect on the rate of erosion, and, in general, the rate was materially reduced by introducing air at the proper location.

There is correlation between the abrasion resistance of concrete and the resistance it will offer to the forces of cavitation. Concrete with a given maximum size of aggregate that is comparatively resistant to shot-blast was also more resistant to cavitation. Grout and mortar specimens were less resistant to abrasion but more resistant to cavitation than concrete specimens of the same strength. Fig. 4 shows how abrasion

TABLE 1—RESISTANCE OF CONCRETE TO EROSION

Mix No.	Variable under study	Resistance (HCISI)*			W/C	Compress. strength 28 days (psi)	Type and blend of cement
		Cavitation		Abrasion			
		28 days	90 days	28 days			
1	W/C = 0.45	70.7	....	1.06	0.45	4490	Type II
2	W/C = 0.50	48.7	....	1.00	0.50	4430	Blend A
3	W/C = 0.55	42.1	....	0.95	0.55	4030	
4	W/C = 0.60	29.5	....	....	0.60	4025	
5	W/C = 0.65	27.6	....	0.87	0.65	3585	
6	W/C = 0.70	9.9	....	....	0.70	3185	
7	Slump = 1 in.	23.6	....	0.72	0.55	3590	Type II
8	Slump = 2 in.	37.8	....	0.85	0.55	3975	Blend A
9	Slump = 3 in.	42.1	....	0.95	0.55	4030	
10	Slump = 4 in.	47.1	....	0.99	0.55	4130	
11	Slump = 5 in.	32.1	....	0.88	0.55	3980	
12	0 percent air	27.7	50.0	0.94	0.55	4400	Type II
13	2 percent air	22.6	47.4	....	0.55	4350	Blend B
14	4 percent air	12.2	19.3	0.92	0.55	3800	
15	6 percent air	9.9	15.7	0.83	0.55	3540	
16	0 percent air	23.8	51.0	0.95	0.59	4270	Type II
17	2 percent air	21.7	37.3	....	0.55	4240	Blend B
18	4 percent air	23.3	43.5	0.95	0.49	4420	
		14 days	28 days				
19	Nontreated surfaces	3.3	6.2	0.77	0.46	2300	Type II
20	Vacuum treated	13.4†	23.0	0.92	0.46	2725	Lehigh
21	½-in. rigid absorptive lining	3.9	13.8	....	0.46	....	with 40 percent
22	Hydron form lining	4.2	9.2	0.74	0.46	....	fly ash

*HCISI—Hours to erode 1 cu in. for each sq in. of surface exposed to erosion.
†This specimen was exposed for a period of 10 hours before it eroded as much as the untreated specimen in 3 hours. The average rate of erosion was measured at 3, 6, and 10 hours and found to be nearly constant throughout the exposure.

NOTES

Aggregates were uniformly graded up to 1½ in.
Except where otherwise noted, the slump was approximately 3 in.
Results of cavitation tests are average values of two exposures. Results of abrasion tests are average values of six exposures.

resistance of concrete varies with the water-cement ratio. Although the scale of Fig. 4 is too small to illustrate much of a change in abrasion resistance within the limits of water-cement ratios shown, there is a definite increase in abrasion resistance with reduced water-cement ratios as expressed by the regression equation shown with the curve.

Of the coatings applied to concrete shown in Fig. 6, only the thick coating of Neoprene shows promise of effectively protecting the concrete from the forces of cavitation. The 1-in. rubber slab with wedge-shaped edges protruding downward and embedded in a concrete specimen has resisted the forces of the cavitation test for 50 hours without damage. As shown in Fig. 7 the rubber slab did not cover the entire test surface.

A sheet-metal plate $\frac{1}{32}$ in. thick welded to a bolt embedded in the concrete was used to cover the concrete not protected by the rubber slab. As the figure shows, the rubber slab remained undamaged after 50 hours of exposure, whereas the sheet metal was severely damaged.

Fig. 8 shows the effect of the cavitation forces on a milled mild steel plate embedded in concrete and on protective coatings on steel. The attack in the cavitation machine used in these tests is not extremely severe, as indicated by the lack of any serious damage to the metal in the machine itself, or to the mild steel plate shown in Fig. 8. A stainless steel coating, arc welded to a mild steel plate, withstood the cavitation attack for 100 hours without damage; although a coating of 12 percent chrome steel flame sprayed on to a mild steel plate was severely pitted after 15 hours of exposure. Fig. 8 also shows that the Neoprene tested in this series is more effective than the Thiokol as a protective coating on steel. Comparison of Fig. 6 and 8 shows that the bond of Neoprene and Thiokol to steel is considerably stronger than it is to concrete. Results of tests on the specimens shown in Fig. 6, 7 and 8 are shown in Table 2.

CONCLUSIONS

1. Through proper proportioning, placing, surface treatment, and curing, the resistance of concrete surfaces to cavitation erosion may be extended three or four times, but even the best concrete will not resist the forces of cavitation for a prolonged period.

2. Heavy rubber coatings bonded well to the surface of the concrete and which remain resilient are effective in protecting the concrete from the forces of cavitation.

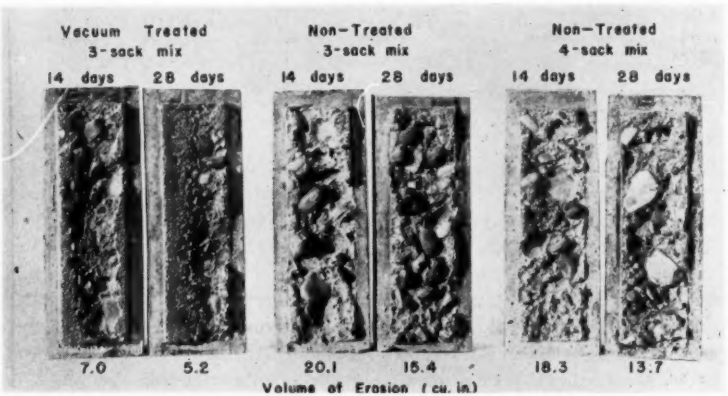


Fig. 5—Resistance of concrete to cavitation after 3 hour exposure to cavitating stream. Trial mixes for Hungry Horse Dam (40 percent fly ash in each mix)

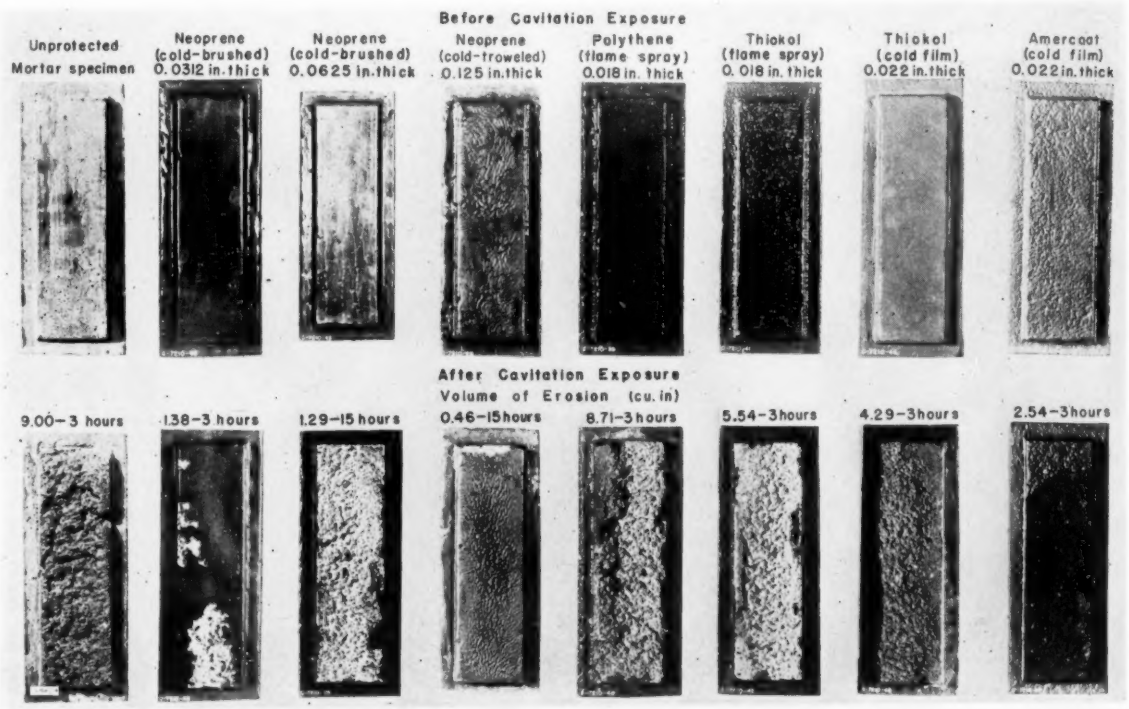
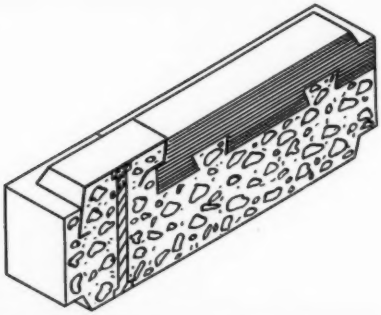


Fig. 6—Resistance to cavitation of protective coatings on concrete



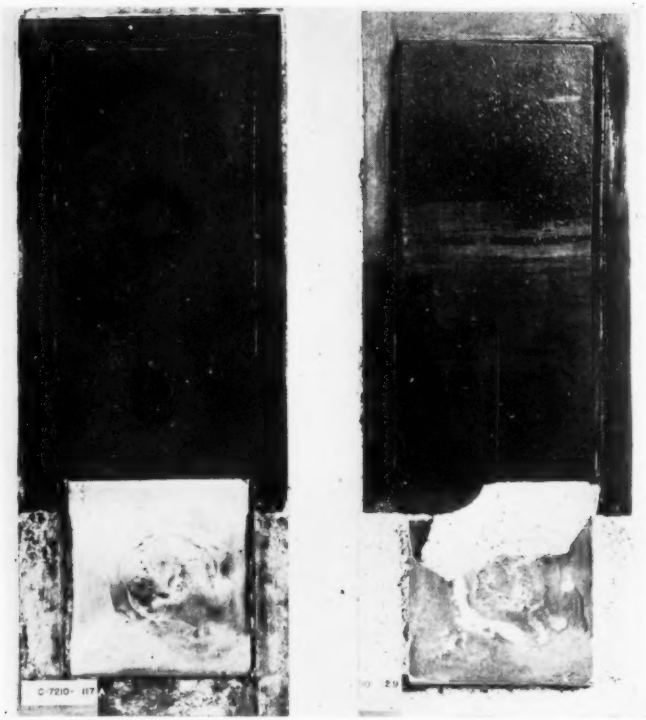


Fig. 7—Cross section (top) of specimen with protective coating of rubber and steel. Rubber plate embedded in concrete with steel plate covering bottom part of specimen before (left) and after (right) exposure

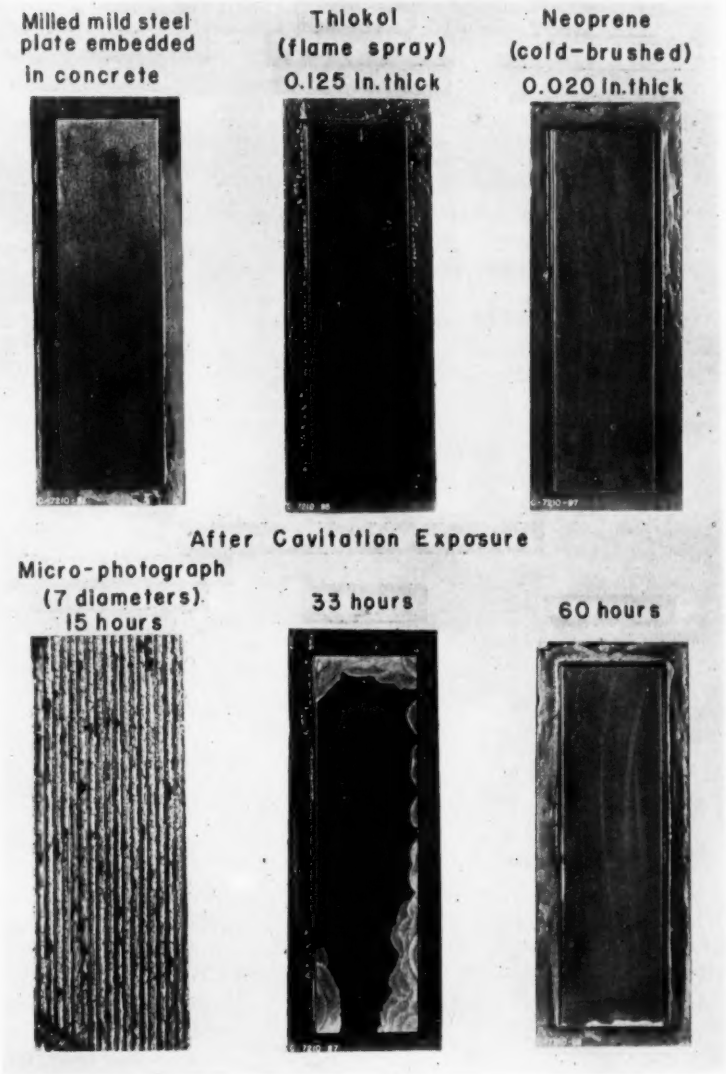

Milled mild steel plate embedded in concrete
Thiokol (flame spray) 0.125 in. thick
Neoprene (cold-brushed) 0.020 in. thick
After Cavitation Exposure
Micro-photograph (7 diameters) 15 hours
33 hours
60 hours

Fig. 8—Resistance to cavitation of protective coatings on steel; before (top) and after (bottom) exposure to cavitating stream

TABLE 2—RESISTANCE OF PROTECTIVE COATINGS ON CONCRETE AND STEEL TO CAVITATION EROSION

Name of coating	Type of application*	Thickness applied, in.	Surface coated	Hours of exposure	Percent of coating removed by cavitation
Neoprene	Cold brush	0.0312	Concrete	3	20
Neoprene	Cold brush	0.0625	Concrete	15	100
Neoprene	Cold trowel	0.1250	Concrete	15	4
Amercoat	Cold brush	0.0220	Concrete	3	85
Thiokol	Cold brush	0.0220	Concrete	3	100
Thiokol	Flame spray	0.0180	Concrete	3	100
Polythene	Flame spray	0.0180	Concrete	3	100
Rubber plate	Embedded in concrete	1.000	——	50	0
Neoprene	Cold brush	0.0200	Steel	60	2
Thiokol	Flame spray	0.1250	Steel	33	25
12 percent chrome steel wire	Flame spray	0.0625	Steel	15	Severe pitting
Mild steel plate	Embedded in concrete	0.5000	——	15	Slight pitting
Stainless steel, welded on mild steel	Welded on mild steel	0.1250	Steel	100	0

*Application and curing techniques were in accord with the manufacturer's recommendations.

3. The best means of protecting concrete from the forces of cavitation is the elimination of these forces, whenever possible, by proper design and construction procedures which will produce smooth uniform flow in the hydraulic structures.

4. Additional tests should be made to investigate the weathering resistance of coatings applied to exposed concrete surfaces, the feasibility of protecting concrete from the forces of cavitation with rubber slabs, the effect of the properties of concrete on its erosion resistance, and the effect of introducing air into the water upstream from the cavitation area upon the intensity of the cavitation forces.

Economy in construction is suggested by

Vacuum Processes Applied to Precast Concrete Houses*

By K. P. BILLNER† and BERT M. THORUD‡

SYNOPSIS

The use of vacuum processes in precast concrete construction simplifies the building of fire-resistant, durable structures designed to permit the maximum use of like units. Vacuum processes have thus far been used in one- and two-story houses and one-story industrial or warehouse structures, but further developments should make possible similar benefits for multi-story construction.

The specific vacuum methods utilized are: (1) extracting excess water from freshly placed concrete prior to set, thereby increasing early strength and enabling early handling of units, (2) holding forms in place by vacuum and (3) handling and placing finished and hardened concrete units by cast-in-place closures formed and quickly hardened by vacuum processes.

The use of these methods results in high strength monolithic construction having exterior and interior finished surfaces, with insulation incorporated into the construction, if desired.

INTRODUCTION

Vacuum processing of concrete is simply the extraction of excess water from concrete immediately after it is placed and screeded to its required level.§ Special lined mats or forms are supplied with vacuum through hose connections and hose lines connected to vacuum tanks in which vacuum is maintained by an engine-driven pump. The vacuum, which may vary from 20 to 24 in. of mercury depending on the tightness of seals in the mat or form lining, readily extracts much of the excess water required in concrete for plasticity. As the excess water is extracted in a few minutes, prior to initial set, the water-cement ratio of the concrete is greatly reduced and the concrete hardens quickly to

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§Lockhardt, William F., "Vacuum Concrete," ACI JOURNAL, Jan.-Feb. 1938, *Proc.* V. 34, p. 305.

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become self-supporting. The actual time depends on the vacuum applied and the depth and volume of the concrete. As initial set has not occurred at this stage, the surface of the concrete, while sufficiently hard to show no imprints from a person standing on it, can still be trowel finished in the usual manner, or may have thin, integrally colored cement applied and finished with perfect bond, with much less time required for such troweling or finishing than for unprocessed concrete. The thinner the concrete section the more effective is the extraction of excess water and resultant hardening of the concrete. Thus, as most precast concrete work applicable to building construction is of relatively thin section, the forms can be removed almost immediately after processing, and the precast units lifted, moved and placed within a few hours.

PROCESSING EQUIPMENT

Job forms are largely eliminated in precast construction, but such forms as are required, chiefly for edges of wall, floor and roof panels and exposed surfaces of cast-in-place closure joints, are easily set and held in place with vacuum. The forms are used on a casting bed or floor slab for horizontally cast units, or set against fixed-in-place surfaces of units adjacent to closure joints. These portions have sealed vacuum spaces and opening of a valve in the vacuum line immediately secures the form in place. No through wall ties or exterior bracings to hold forms are required. Such forms, properly made for multiple reuse, can be set in a few minutes.

Special stiffened mats fitted with a sling for attachment to a crane are used for lifting units from their casting beds and for tilting, moving and erecting the units (Fig. 1). These mats have sealed vacuum spaces

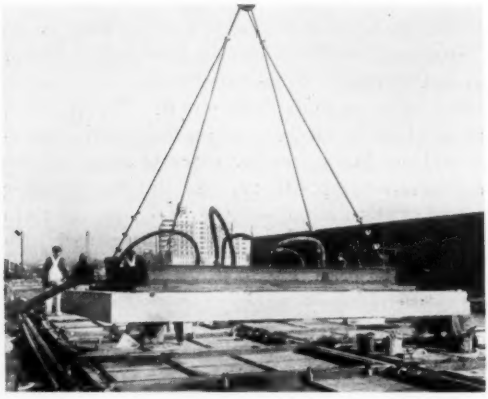

Fig. 1—Lifting precast concrete floor slabs from casting molds

for application to the surface of the concrete unit. By gripping the precast units uniformly over large surfaces, no damaging bending moments occur. Since most forms are concave the units are easily removed. Compressed air is injected under complex flanged panels to loosen them. Off-center attachment of the slings permits tilting the wall panels from a horizontal to a vertical position (Fig. 2). No objectionable and costly lifting anchors are required.

DESIGN AND CONSTRUCTION

To make the best use of vacuum processes, structures must be designed to permit the use of the largest practicable precast units. Thus, fewer separate pieces are handled in erection and a minimum of edge forms and closure joints are required. Panel sizes are limited only by the capacity of available cranes, or possibly by available trucks for transporting if the panels are cast in a yard away from the building site.

Foundations

The only departure from usual design is the provision for a tapered slot on the top surface into which the precast wall slabs are keyed.

Exterior walls

Three types of exterior walls are shown in Fig. 3a and 3b. For one-story houses a laminated wall with faces of structural concrete connected to each other by light trussed steel reinforcing bars provides finished interior and exterior surfaces requiring only paint, if not colored integrally. The center core consists of an insulating concrete such as Aerocrete, vermiculite or perlite. A 6-in. wall of which $2\frac{3}{4}$ in. is

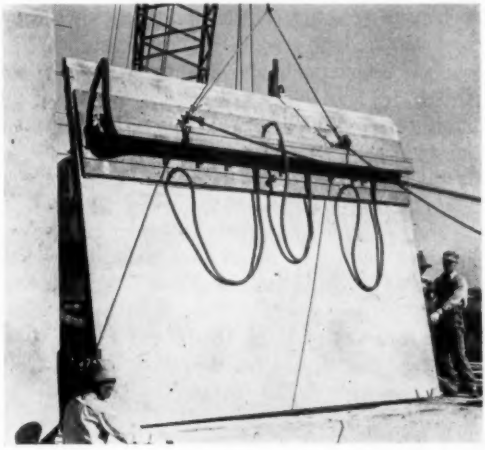

Fig. 2 — Tilting precast warehouse wall into place

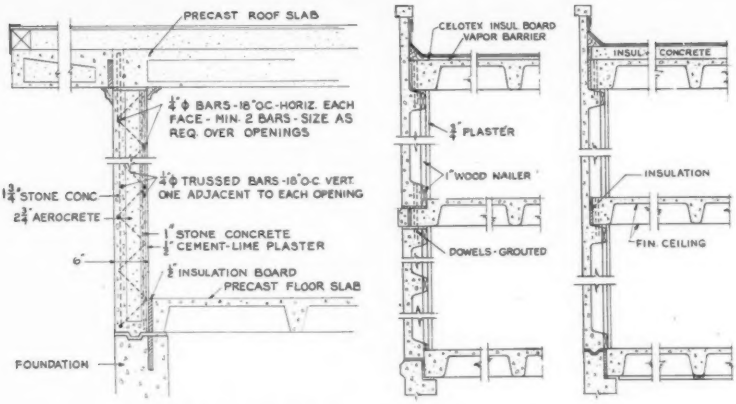

Fig. 3a (left)—Typical exterior wall—laminated construction

Fig. 3b (right)—Typical exterior walls—ribbed construction

Aerocrete weighing 27 lb per cu ft has a U* value of approximately 0.28 with a 15-mile exterior wind. A solid brick wall of corresponding value would be 16 in. thick. If the floor is of concrete, these walls can be readily cast on it. By placing canvas on the floor in sheets larger than the slab, so that the edge forms can be set on the canvas to hold it firm and taut, smooth interior concrete surfaces are obtained. These surfaces have the texture of the canvas and generally are free from air-pitting. The interior structural concrete, usually 1½ in. thick, is placed first, of which the first ½ in. is a cement-lime-sand mix placed and screeded to receive the reinforcing steel. After the steel is placed, the remaining inch of concrete is added, screeded and vacuum processed. Then the insulating concrete is poured or placed as precast units set in cement grout between the trussed steel bars. The insulating concrete is not vacuum processed as consolidation decreases its insulation value. Finally, the exterior face concrete is placed, screeded, vacuum processed and then floated, troweled or plastered as desired.

For one- and two-story houses, a ribbed wall of stone concrete may be used, having a smooth integral exterior finish and requiring the application of separate interior finish on the ribbed side. The wall section (Fig. 3b) consists of a 2-in. solid outer shell having vertical ribs, or studs, spaced 16 to 24 in. on centers on the inner side. The vertical ribs are generally 4 in. deep over-all, with tapered sides to make for easy removal of the cast section from the mold. The casting mold

*Over-all heat transmission coefficient expressed in BTU per hour per sq ft per degree difference in temperature of the air on opposite sides of the wall.

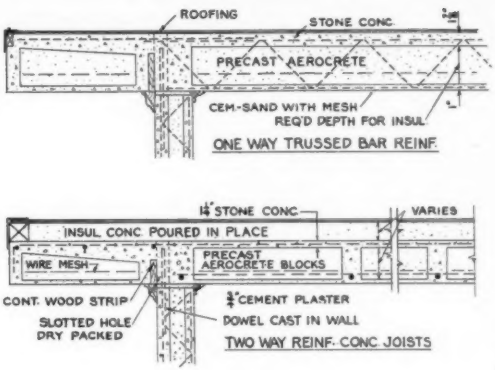

Fig. 4—Laminated roof slabs

usually is made of concrete from a wood or metal pattern of the wall or rib. Horizontal bearing members are introduced at the bottom and top of each story, and if required, at mid-story or window-sill height for lateral stiffening. A minimum of 0.25 percent steel mesh or bars reinforces the slab vertically and horizontally. More may be required to offset local wind pressures. The vertical studs contain a single vertical bar, usually a ⅜ in. round, near the interior face. These walls provide maximum strength with a minimum of concrete and reinforcement, and with many duplicate panels, this construction is extremely economical.

The walls are erected on the footings by setting in grout or mortar. Steel shims are placed in the footing slots to maintain specified joint thickness and elevation above the foundations until the grout hardens. Spaces between separate wall units and at corners into which anchor rods extend from the slabs are then formed with vacuum-held forms for poured-in-place vacuum-processed closure joints.

For warehouses and industrial buildings, where insulation and conductivity through the walls is not important, solid slabs of stone concrete of uniform thickness have been used. They often are combined with poured-in-place closure columns which serve as structural support for the roof framing or for wind resistance only where the roof is carried entirely on interior columns.

Floor and roof slabs

Two types of floor and flat roof slabs have been used, one of laminated construction having a flush ceiling and the other of ribbed joists supporting a thin flat slab (Fig. 4 and 5).

The laminated slab utilizes lightweight insulating concrete fillers which form ribs for one- or two-way reinforcing above a flat integrally

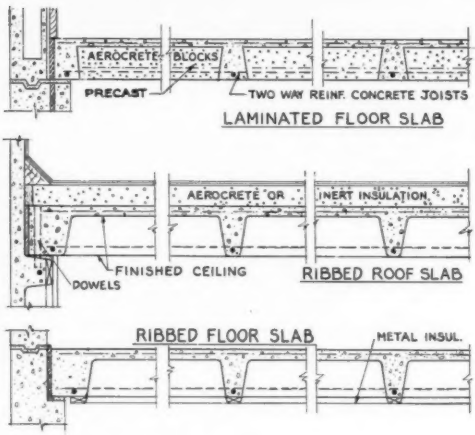

Fig. 5—Typical floor and roof slabs

cast slab ceiling. The fillers may be precast, preferably so for two-way joists or rib reinforcing, or cast in place. With the reinforcing arranged as a trussed bar joist designed to take all bottom tensile stresses and diagonal tension or shear in the webs, the continuous insulating concrete provides both insulation and sound deadening.

The ribbed slabs are cast on molds similar to those described for ribbed walls, the spaces between the ribs, or joists, forming a paneled soffit which can be left exposed as the finished two-way beamed ceiling. Smooth surfaces are obtained by carefully placing concrete in smooth concrete molds. The molds are coated to make removal of the cast concrete easy.

For the usual spans in houses, the two-way reinforced slabs can easily be designed for edge beams of the same depth as the remainder of the floor. That is, as a girderless floor with interior corners, or intersections of the edge beams, supported on interior cast-in-place or precast concrete or lally colums.

Joists between separate panels provide space for placing a packed stiff mix of cement and sand. Anchor rods extend into such joints to bond the slabs to each other.

Pitched roofs

For pitched roofs, precast reinforced concrete trusses spaced approximately 7 ft on centers have been used (Fig. 6). These may be arranged to support lightweight nailcrete slabs or thin solid slabs with nailers over which asbestos cement or wood shingles can be nailed. Wood rafters with wood sheathing and any type of shingles also may be used. Ceilings may be of lightweight concrete ribbed-channel slabs, with the

ribs set on top to provide a flush ceiling, either supported by the lower chord of the truss or on precast concrete interior partitions.

Interior partitions

Interior partitions, either load-bearing or nonload-bearing, can be made readily of precast concrete. The nonload-bearing type is relatively thin and usually is made of lightweight concrete. In load-bearing partitions requiring ample concrete strength, stone or aggregates such as waylite, haydite or cinders are used.

APPLICATION

A typical application of vacuum processes is illustrated by a project consisting of 585 two- and 3-bedroom houses. Each two-bedroom house had 12 reinforced concrete panels, 8 for the walls and 4 for the roof, with 4 additional panels for the attached garage, 3 for walls and 1 for the roof. While the cast-in-place concrete foundation and floor were being placed, the first step in the construction of the precast panels for the shell was the careful fabrication of a wood pattern for each panel. From it negative concrete molds were made which permitted multiple casting of identical panels. The molds were cleaned and oiled, the reinforcing steel set and the concrete placed and screeded. Then large vacuum mats covering the whole panel were placed on the screeded concrete and the concrete was processed by vacuum for approximately 10 minutes. The vacuum mats were then removed, the surface was trowel-finished to the desired surface texture, and the panel allowed to cure until the next day. Within 16 hours the concrete was strong enough to permit lifting the panel off the mold. Since the roof panels were covered by insulation and roofing they needed only troweling to obtain smooth level surfaces for the lifter. The wall panels, however, were covered with a troweled surface of colored sand and cement so that no additional treatment except for final cleaning was required after erection.

The inside of the wall panels, formed to create vertical studs and

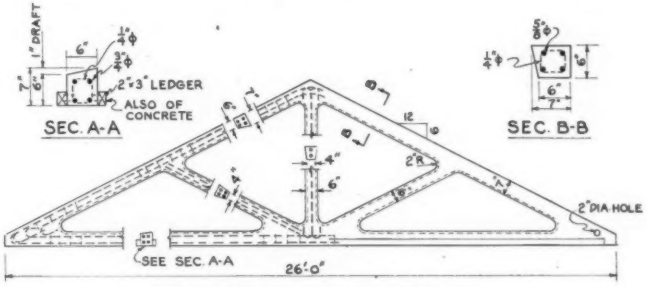

Fig. 6—Precast concrete roof truss

horizontal stiffening ribs in the erected wall, had wood nailing strips attached to the inner studs and ribs (Fig. 3b). Rock wool bat insulation with vapor seal was placed between the studs and ribs and attached to the wood nailers. Plaster board was then attached to the nailers. Three-quarter-inch insulation board was placed between the ends of the concrete roof panels and the interior face of the wall and between the concrete floor on fill and the foundation wall to prevent conductance through the concrete. This, together with the insulation over the roof panels and in the wall panels, prevents dampness on interior surfaces.

The roof panels were 1¼-in. slabs between 8-in. reinforced concrete ribs, or joists, extending in two directions, thus forming a coffered ceiling. These panels weighed only 25 lb per sq ft between the heavier edge beams which rested either on the wall or formed structural beams between the supporting columns. The ribs were spaced 3 ft or less on centers depending on room sizes.

The coffered underside of the roof panels was left exposed as finished ceiling since the smooth finished concrete surfaces needed only a decorative finish after erection.

Wall panels were set in a grouted joint keyed into the top of the foundation wall (Fig. 2) and were joined together by poured-in-place concrete closure columns. The vertical edges of the wall panels were keyed and the horizontal reinforcing steel extended into the poured joint. Vacuum processing forms were used for these joints and were held in place by vacuum holders which attached to the erected wall panels. They were set in place by two men in two minutes. The exterior faces of these joints were trowel finished, immediately after the forms were stripped, with the same colored cement and sand plaster used on the precast wall panels. The roof panels were set directly on top of the wall panels and columns and anchored to them by vertical dowels set in large holes and grouted in place.

SUMMARY

This method of construction together with the poured-in-place joints and the type of anchorage used results in a fire-proof monolithic reinforced concrete structure. By means of vacuum processes the concrete attains an ultimate strength of at least 6000 psi, and the concrete surfaces are exceptionally wear resistant and free from dust. The early hardening and increased strengths obtained also reduce the possibility of shrinkage cracks occurring in the concrete. This construction, while much more durable than ordinary wood frame construction customarily used for low cost housing, compares favorably to it in cost. The actual saving on any particular project depends, of course, on the number of typical houses and the number of panels cast from each mold.

A new-type consistency meter for determining the workability of the mix, while in the mixer drum, tested at Allatoona Dam.

New Type of Consistency Meter Tested at Allatoona Dam*

By JAMES M. POLATTY†

SYNOPSIS

Various mechanical devices have been developed for indicating consistency of concrete since the early days of visual inspection after discharge from the mixer. A new type meter to measure the consistency of concrete while it is being mixed was tested at Allatoona Dam and the operation and results are described.

INTRODUCTION

Consistency relates to the character of the concrete mix with respect to its fluidity. Consistency, plasticity and workability are interconnected and are essential to the production of good concrete. Experience has demonstrated that under conditions where free water is variable and the cement and aggregate are properly batched, consistency control is the all-important and effective assurance of a good job.

The flow table, slump cone and visual inspection, used to indicate the consistency of concrete, are used after the concrete is discharged from the mixer, making it impractical to correct any apparent irregularities in the batch so tested. Corrections can be applied only to subsequent batches.

Consistency meters

The demand for some means of measurement of workability and consistency of concrete while it is being mixed in the mixer drum encouraged the development of various mechanical indicators (one as early as 1928).‡ Many methods have been advanced since that time.

One meter¶ was designed to indicate the relative pressures exerted

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‡Rayburn E. B., Jr., "Consistency Indicator for a Ready-Mixed Concrete Plant," ACI JOURNAL, Nov.-Dec. 1934, *Proc.* V. 31, p. 105.

¶Roberts, Emory D., "Determining Characteristics of Concrete in the Mixer Drum," ACI JOURNAL, Sept. 1931, *Proc.* V. 28, pp. 59-72.

on a bar by the concrete as it was being mixed in the mixer. An oil gage, registering pressure, gave an index of the pressure on the bar.

A "mixometer" had a truncated cone placed in the discharge end of the mixer drum and concrete picked up by the discharge buckets of the mixer was dropped into this truncated cone. The speed at which the concrete passed through the cone, compared to the speed with which it was discharged by the buckets into the cone, gave an indication of the consistency of the concrete.

A meter used at Grand Coulee Dam* operated by changes in the center of gravity of the batch in the mixer as the consistency changed. The mixer bowl or frame was supported by springs which deflected with changes in position of the mix as it varied from dry to wet.

More recently, a recording wattmeter has been used which indicated changes in consistency by changes in power required to turn the mixer as the batch varies from dry to wet.

In an attempt to satisfy the specification requirement for a consistency meter, *i.e.*, one that would show a change of one inch in slump, a power input type recording wattmeter was installed at the Allatoona project. This type of meter was of little practical value in determining the consistency of the concrete as it was mixed. This was due, it is believed, to the slight difference in power demand during the mixing period between wet and dry batches of an air-entraining mass concrete with a low cement and water content.

Therefore, a new type of consistency meter, called a "Plastograph," invented by Glenway Maxon, was tested at Allatoona Dam with favorable results.

TESTS OF THE PLASTOGRAPH

Mixer

The 525,000 cu yd of concrete for Allatoona Dam were mixed in two 4-cu yd, rear charging, front discharging, tilter type Smith mixers. The drum of this mixer consists of a cone shaped front and back section connected by a cylindrical center section. The mixing blades, consisting of 3 charge and 3 discharge blades, are set in a herringbone pattern so as to interrupt the flow of concrete in the drum. Both the charge and discharge blades extend well across the center of the drum but leave a gap or orifice at their intersection through which the concrete flows during mixing. Concrete, during the mixing period, flows intermittently in one direction while the blades and drum rotate at a constant speed in the opposite direction. The flow of concrete is interrupted by the mixing blades which act as a funnel or chute to direct the flow toward the center of the mixer.

In theory, this means that the concrete during mixing is moved from both ends to the center of the mixer, but in actual practice, care

*"Grand Coulee consistency meters," JPP 35-16, ACI JOURNAL, Jan. 1939, *Proc.* V. 35, p. 204.

must be taken in the batching sequence of water and cement to obtain efficient mixing due to the better mixing action if the materials travel from back to middle of the mixer rather than front to middle.

Plastograph

The measurement of consistency by the Plastograph is a function of the flow of concrete while it is being mixed and is based on the fact that sloppy concrete flows easier than stiff concrete, thereby giving an indication of the mixture workability and consistency while it is still in the mixer.

In the test mixer used, the gap or orifice at the intersection of the charging and discharging blades was enlarged. The enlarging of this gap provided greater opportunity for the concrete to flow from both ends of the mixer towards the center. The two blades, acting as a funnel or flume, directed this flow to the center of the mixer where the concrete flowed through the opening and spread out to impinge on a reaction bucket.

The inverted V-shaped reaction blade or bucket (A in Fig. 1) was installed directly below the gap formed by the intersection of one of the sets of charge and discharge blades. This bucket is mounted on a pivotable shaft (B in Fig. 1) parallel to the axis of and extending through the side of the mixer. The flow of concrete through the gap impinges on the outside of this V-shaped blade, rotating the shaft a few degrees counterclockwise, which in turn rotates an external wiper or shoe (D in Fig. 1) onto the path of a series of electrical contact points called probes.* This shaft rotation, limited by a stop on the outside of the mixer, causes the closing of one or more of the eight indicator circuits.

In Fig. 1, (C) is the plate that is welded to the outside of the mixer and (E) is the support bearing for the mechanism. Fig. 2 shows the

*The word "probe" is used by electronic engineers in the sense of a "reaching out for a signal" with particular reference to signals picked up by antennae; in this case, applied to the electrical contacts.

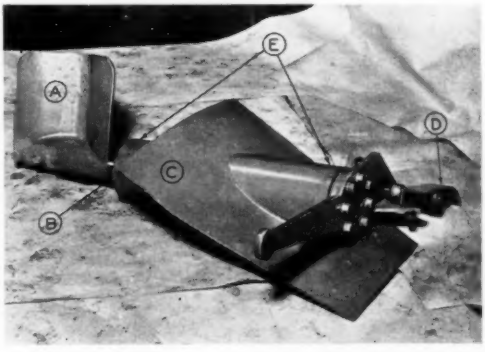

Fig. 1—The concrete strikes the back of the V-shaped bucket (A) mounted on a pivotable shaft (B), rotating the shaft a few degrees counterclockwise, which in turn rotates an external shoe (D) onto the path of the probes. (C) is the plate welded to the outside of the mixer and (E) is the support bearing.

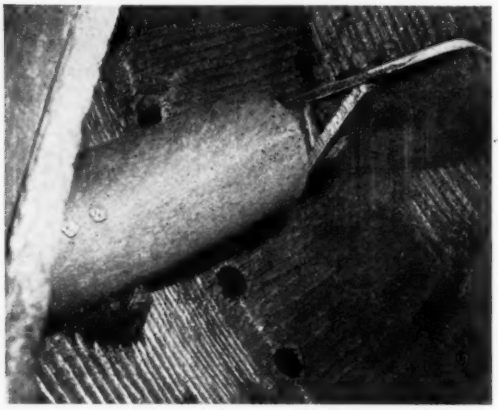

Fig. 2—Bearing and reaction bucket installed in the mixer drum

bearing and reaction blade installed in the mixer. Fig. 3 is a view of the front of the mixer showing the location of that part of the meter which is attached to the outside of the mixer and the contact system attached to the frame. The adjustable resistance spring located above the contact shoe controls the sensitivity of the meter.

Probes

Placed radially around the circumference of the mixer and attached to the mixer frame are eight probes (Fig. 3), which when deflected by the contact shoe close an electrical circuit. The probes are insulated from and are equidistant from the axis of the mixer. They are adjustable about the circumference of the mixer, thus providing an adjustment to conform to various degrees of flowability.

The contact of the shoe on any one probe, representing the start of flow at the position of this probe, results in the shoe making contact with all other probes to the right of the first closed probe.

For example, if probe (6) (See Fig. 4 for location and numbering of probes) is closed by the contact shoe, then probes (5), (4), (3) and (2) are in turn also closed indicating the start of flow at probe (6) and a continued flow at the other points metnioned.

Operation

Fig. 5 is a line drawing of the front end of the mixer with (A) representing the contact shoe and (2), (3) and (9) representing three of the eight probes. The entrance of the materials into the mixer causes the blades, which are rotating in a counterclockwise direction, to carry the mix up beyond the position indicated by line YY to a position indicated by probe (2) where there is sufficient flow due to the weight

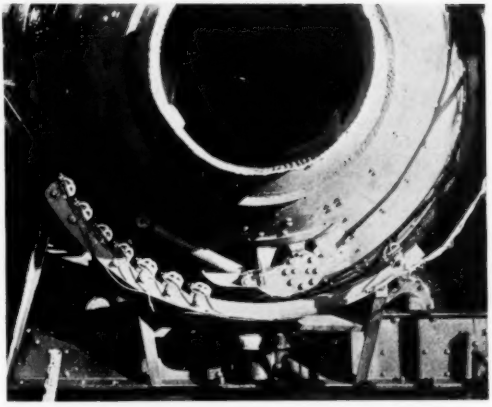

Fig. 3—The eight probes are equidistant from the axis of the mixer and are adjustable about the circumference to conform to various degrees of flowability.

of the materials through the 2-blade orifice to rotate the reaction blade, resulting in the shoe making contact with probe (2). As the mix becomes more plastic, the beginning of this flow point approaches line YY. As the water and cement are more thoroughly distributed through the mix, resulting in a concrete mix that will readily flow through the blade orifice, this starting point of flow passes line YY and approaches probe (3). As the concrete nears the condition of thorough mixing, the starting point of flow passes probe (3) and approaches probe (9), stopping at some intermediate point between probe (3) and probe (9), which indicates the consistency of the mix. The position of the reaction bucket at the time the plastic concrete flows against it is a function of the degree of plasticity.

Thus we have probe (2) indicating practically no flow in the mix, probe (3) indicating an increased flow, and probe (9) representing an extremely high flow of the concrete. Increasing the water content results in an increased flowability or workability, which is indicated

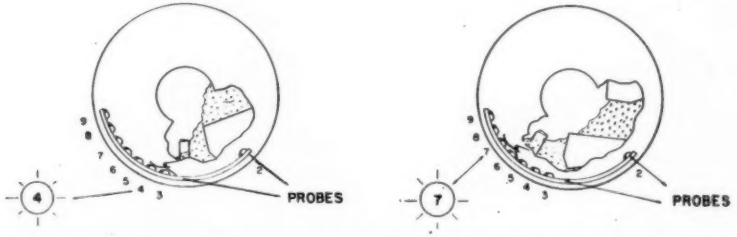

Fig. 4—Two positions of the shoe making contact with the probes, dry concrete (left) and wet concrete (right)

by a larger probe reading. Fig. 4 depicts a dry mix making contact on probe (4) and a wet mix making contact at probe (7). Water added while mixing will advance the instant of impact.

Fig. 6 shows the indicators and relay box. A wire from each of the eight probes and a ground to the mixer are carried in a single cable to a relay box (A). The circuits from the probes have extremely low voltage and are amplified by the electronic relay box to 110 volts. Connected to this box are two types of indicators, one a regular Esterline Angus recorder (C) and the other a light panel (B) consisting of a large light that tells when the meter is in operation and eight small indicator lights, each of which flash when a corresponding circuit is closed by probe contacts. The recording chart has proved to be the better of the two indicating devices.

Batch comparison

Fig. 7 compares three batches of a three bag per cu yd mix with 6-in. maximum size aggregate. Each vertical line of dashes represents one revolution of the mixer and the numbers on the chart correspond to the probe meter number. The mixing time for each batch is indicated at the bottom of the chart with the time the materials entered the mixer being shown on the right of the chart and the discharge point on the left side. In an effort to assign a numerical value to the chart readings, several methods have been tried. The one offering the most consistent results has been to use the last ten revolutions of the mixer prior to dumping. The presence of skips, *i.e.*, failure of one of the probes to print, offered a problem, but the use of an arbitrary method of filling in these skips with dashes taken from the higher readings offered a fairly acceptable method of assigning a numerical value to the reading.

Batch 60 was mixed for 2½ minutes. Reading from right to left, the charts show that the concrete materials were in the mixer for the

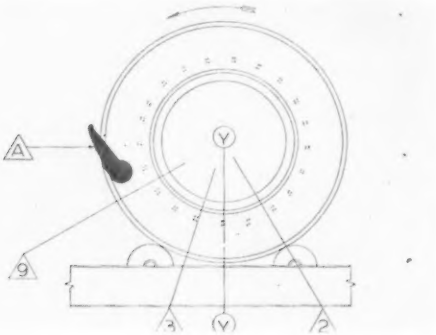

Fig. 5—Front end of the mixer with (A) representing contact shoe and (2), (3) and (9) representing three of the eight probes

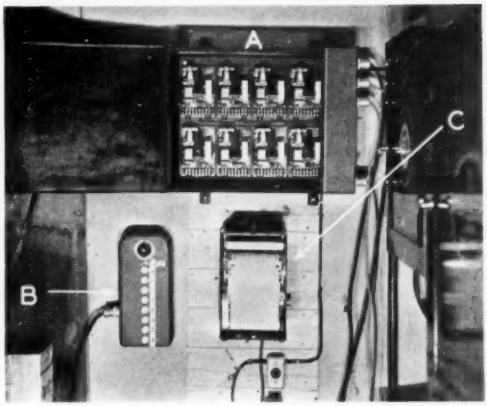

Fig. 6—Indicators and relay box—(A) electronic relay box, (B) light panel and (C) Esterline Angus recorder

first eight revolutions of the mixer and flowed enough to move the reaction blade at the position of probe (2) on each of the 24 revolutions. The start of this flow indicates the point at which enough of the mixed material had entered the mixer to produce sufficient weight to move the reaction blade. After one minute mixing time, or nine revolutions

BATCH NUMBER	WEIGHT OF WATER (lb)	WORKABILITY IN FORM	METER READING	SLUMP (in.)
60	704	GOOD DRY	3.9	1.00
8	747	GOOD	5.3	2.50
2	773	WET	6.1	4.25

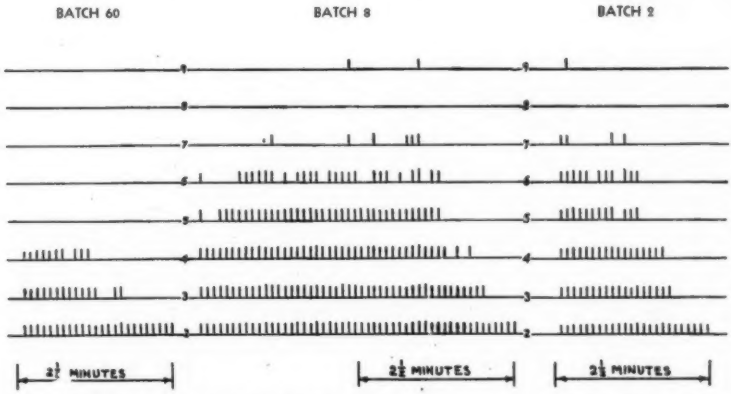

Fig. 7—Comparison of three test batches with the batch entering the mixer on the right of recording chart and discharging at the left

of the mixer, flow commenced at the position of probe (3) and continued until dumping with only two skips. Flow commenced at the position of probe (4) after about 1½ minutes and continued until dumping with only one skip. Using the dash marks for the last ten revolutions prior to the elapse of the 2½ minute mixing time, an indicator number of 3.9 was assigned to the batch. The 3 coming from the third probe and the 0.9 from the fourth probe. This batch with a 1-in. slump was judged "good-dry" by the placing inspector, meaning that it was placeable but a little on the dry side.

Batch 8, with 2½-in. slump, was mixed for 5 minutes or twice as long as Batch 60 and started drying up after 4 minutes. The meter reading at the end of 2½ minutes was 6.1, the line for probe (6) having three skips which were made up by taking three dashes from the probe (7) line, leaving a reading on this line of 0.1, or a total reading of 6.1. At the end of 5 minutes the reading on the probe (5) line had two skips to make up and the probe (6) line had five dashes, which left 0.3 on that line, or a total reading of 5.3.

Batch 2 was a wetter batch with a meter reading of 6.1, the placing inspector judging it a wet mix and it had a slump of 4¼ in.

CONCLUSION

In general, the following observations were made of the meter performance in mixing a three bag per cu yd concrete with a 6-in. maximum aggregate.

1. The Plastograph showed satisfactorily the workability of the mix at various times during the mixing operation.
2. The meter indicated a moisture change in time to make a correction either in the same batch or on the following one.
3. The Plastograph is a better indicator of mass concrete workability than any type of meter that the writer has observed, being considered superior to a recording wattmeter or a slump test.
4. A change in the gradation of aggregates will cause a change in the meter reading.
5. The meter works extremely well with 6-in. maximum size aggregate, fairly well with 3-in., and fair with 1½-in.
6. The electrical circuits on the probes should either be waterproofed or protected from rain to prevent short circuits. A grease or dust coating on the probes will prevent the circuits from closing. The inventor has recently perfected a waterproof probe that offers possibilities.
7. The skips on the recorder, probably due to large aggregates or electrical trouble, made reading of the charts difficult.
8. The method of reading the charts, *i.e.*, using the last ten revolutions of the mixer drum, gave a numerical value to the meter reading that is too precise for field use.
9. The plant inspectors do not use a reading as accurate as described above, but make a batch-to-batch comparison of charts.

The final answer to the efficiency of the meter is that the plant inspectors can and do use it as an aid in controlling the workability of the concrete.

The authors find that usual concrete mixing practices do not develop maximum potential strength of the materials used.

Effect of Mixing Sequence on the Properties of Concrete*

By F. L. FITZPATRICK† and W. SERKIN‡

SYNOPSIS

The order in which the constituents of concrete (aggregates, cement and water) are combined in the mixing operation, has a significant effect upon the properties of the concrete as to workability, strength, density, surface finish and absorption. Tests are reported.

INTRODUCTION

As reported in 1943§ it was discovered, in the course of routine experiments in the testing laboratory of our Melbourne Plant, that significant variations in the tensile strength of mortars arise when the order of combining the constituent materials is varied. This effect of varying mixing procedure seems not to have been noted previously by earlier experimenters, though it has since been confirmed to some extent.¶ Further studies have been made involving tests of relative compressive strengths, slumps and bulk weights when the mixing procedure is varied as to the order of amalgamation of the materials in the mixing process. These confirm the tendency earlier reported, and appear to establish definitely that it is desirable to: (1) mix cement and fine aggregate, (2) add water (so making a mortar) and (3) add coarse aggregate.

Such a procedure, as compared with the more common order of charging coarse aggregate, fine aggregate and cement and then adding the water, tends to produce: (1) higher compressive and tensile strength at the same water-cement ratio, or a lower water-cement ratio and hence still higher strength if the extra workability is not needed, (2)

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§Fitzpatrick, F. L., JPP 39-127, ACI JOURNAL, Feb. 1943, *Proc.* V. 39, p. 312.

¶Serkin, W., "Effect of Order of Mixing on Concrete Strength," *Commonwealth Engineer* (Australia), V. 35, No. 3, Oct. 1, 1947.

better workability and somewhat greater slump for a given water-cement ratio and (3) greater bulk weight—hence greater density.

Additional experiments, since those reported earlier, are described below. In all cases perfectly dry aggregates were used.

COMPRESSIVE STRENGTH

The composition of the three test mixtures used is given in Table 1. The order of combining the constituents of these mixes is shown in Table 2 as are the compressive strengths of the cured concretes. All mixing was for three minutes in a tilting drum type mixer. Test specimens were 3 x 6-in. cylinders formed according to Australian Standards specification.

TABLE 1—COMPOSITION OF TEST MIXES

Symbol	Constituent	Parts by weight		
		Mix No. 1	Mix No. 2	Mix No. 3
A	Crushed rock (passing ½-in. retained on ⅜-in. screen)		307	307
Aa	Crushed rock (passing ⅜-in. retained on ¼-in. screen)	1050	339	339
B	Coarse sand (Passing ¼-in. screen)	350	168	168
C	Fine sand (Passing No. 20 sieve)	380	168	168
D	Portland cement	445	226	198
E	Water	200	112	112

An appreciable increase in slump (4 in. compared with 2 to 2½ in.) occurred when the mortar was made first and then the coarse aggregate added, as compared with normal mixing procedure.

Bulk weight (*i.e.*, unit weight per given volume when rodded as in making cylinders) was found to be increased approximately 2 percent when mortar was mixed first.

TENSILE STRENGTH

Further experiments were performed to check the effect on tensile strength. The mix constituents in parts by weight were: 150 coarse sand (passing ¼-in.), 150 fine sand, 100 portland cement and 40 water. Tension briquettes were made on an Avery hammer machine and were tested after a storage of 1 day in damp air, 7 days in water, 21 days in open air. Results are shown in Table 3.

In another test series, basalt grit (to reproduce coarse aggregate in miniature) was used for a tension series. The mix constituents in parts by weight were: (A) 450 cement, (B) 900 fine sand and (C) 1350

TABLE 2—COMPRESSIVE STRENGTH IN RELATION TO MIXING SEQUENCE

Order of combining materials	Curing conditions—3 x 6-in. cylinders	Compressive strength, psi—ave. of 4 cylinders
Mix No. 1		
(Aa + B + C) then D added then E added	1 day-damp air 11 days in water	4336
(B + C + D) then E added then Aa added		4719
(D + E) then Aa added then (B + C) added		3807
Mix No. 2		
(A + Aa + B + C + D) then E added	1 day—damp air 6 days in water	2073
(B + C + D) then (A + Aa) added then E added		2160
(B + C + D) then E added then (A + Aa) added		2358
(D + E) then (B + C) added then (A + Aa) added		1773
Mix No. 3		
(A + Aa + B + C + D) then E added	1 day—damp air 6 days in water	2538 2952* 3435†
(A + Aa + D) then (B + C) added then E added		2326
(B + C + D) + E then (A + Aa) added		2802 3728* 3808†
(D + E) added to (A + Aa) then (B + C) added		2013

*First repetition of test at 14 days.
†Second repetition of test at 14 days.

TABLE 3—TENSILE STRENGTH IN RELATION TO MIXING SEQUENCE

Order of combining materials	Tensile strength, psi
Cement, fine and coarse sand mixed dry—then water added	503
Cement and fine sand mixed dry, then water added and mixed, and finally the coarse sand added and mixed in	523

¼-in. basalt grit. Briquettes were stored 1 day in damp air, 7 days in water and 21 days in air. Table 4 shows the tensile strengths recorded.

SURFACE FINISH

Inspection of compression specimens revealed a marked difference between mixes made in the normal way and those in which a mortar

TABLE 4—TENSILE STRENGTH OF BASALT GRIT SPECIMENS

Order of combining materials	8.33 percent water to dry materials by wt — Tensile strength, psi	7.48 percent water to dry materials by wt — Tensile strength, psi
(A + B + C) then water added	423	443
(A + B) then water then C added	496	562
(A + water) then (B + C) added	275	357

was first made, and the coarse aggregate subsequently mixed in. The latter showed a distinctly more regular finish, with freedom from "water marks," *i.e.*, marks on the surface from upward travel of bleeding water. In dry mixes the better workability of the "pre-mortared" mix showed up in the absence of large voids and pockets.

ABSORPTION

Absorption tests, made according to Australian Standard practice, showed 3.9 percent absorption as percentage of dry weight when the mortar was made first and then the coarse aggregate added compared to 4.4 percent for normal mixing procedure.

Specimens were precisely similar except as to order of mixing, and were tested by drying for 24 hours at 150 F, then immersing in water for 24 hours, the gain in weight due to absorbed water then being ascertained.

SUMMARY

Our work seems to have established that when concrete is made by first mixing the fines (sand) and cement, then adding water to make a mortar, and finally incorporating the coarse aggregate into that mortar, significant improvement in concrete quality is achieved. Compared with concrete made by the customary method of charging aggregates and cement and then adding water, there are substantial favorable differences in density, workability, strength, absorption and surface finish (and probably in permeability and durability).

Discussion of a paper by F. L. Fitzpatrick and W. Serkin:

Effect of Mixing Sequence on the Properties of Concrete*

By GLENWAY MAXON, HAROLD H. MUNGER, J. MacNEIL TURNBULL and AUTHORS

By GLENWAY MAXON†

The writer would like to ask the authors a few questions.

1. The partial mixing time of various ingredients is not stated. Could the partial time be included in an addendum?
2. What was the free size of the mixer? A batch of mix No. 1 was apparently over ½ cu yd while mix No. 2 and mix No. 3 were less than ⅓ cu yd.
3. Why was mix No. 3 stronger than mix No. 2 while it contained less cement but the same amount of all other ingredients?
4. What change took place to account for the rather large variations in the "First repetition of test at 14 days," "Second repetition of test at 14 days"?

The usual methods of charging and mixing the ingredients in a tilting mixer in the United States are: (1) water leading all the other ingredients by 5 to 10 seconds and continuing with the balance of the charging; (2) charging of the cement sandwiched between the sand (above) and the stone (below) as rapidly as the mixer will take these ingredients away from the charging orifice; and (3) mixing just as short a time as possible—one minute for any size mixer up to 1 cu yd.

Tests reported by Fitzpatrick and Serkin should be augmented by similar tests in this country. Maybe our mixing time is too short; maybe better results can be had by changing our methods of charging. Does our washout test tell the true story of the quality of the mortar?

By HAROLD H. MUNGER‡

The report by Fitzpatrick and Serkin presents further interesting and convincing data on a subject that is receiving less attention than its importance justifies. If any significant increase in strength and durability can

*ACI JOURNAL, Oct. 1949, *Proc.* V. 46, p. 137. Disc. 46-10 is a part of copyrighted JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, V. 22, No. 4, Dec. 1950, Part 2, *Proceedings* V. 46.

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be obtained by such a simple means as modification of the order of mixing, it is deserving of the most careful study.

A class in concrete mix design at Kansas State College attempts to acquaint the students with the newer developments as well as with long established practice in mix design. Laboratory work consists of a number of brief and highly simplified research projects in which the students investigate the effects of variations in proportioning, mixing, placing and curing concrete.

For two years this course has included a series of batches made of identical materials in the same proportions, but with the order of mixing varied. (See "Effect of Order of Mixing on Concrete Strength" (LR 45-4), ACI JOURNAL, Sept. 1948, *Proc.* V. 45, p. 84) In exactly 100 percent of the trials, the batch in which the water and cement were combined before the addition of the aggregate showed lower strength than that in which all aggregates and the cement were dry mixed before the addition of the water. Various combinations have been tried with results uniformly indicating the desirability of combining the fine aggregate with the cement before adding the water.

These results suggest that the dry cement establishes an intimate contact with the surface of the aggregate that is not entirely destroyed by the addition of the water and so results in improved bond. When the water is first in contact with the aggregate, a film of water may be formed that prevents the development of a complete bond. It was decided to check this hypothesis by testing the relative resistance to freezing and thawing of a number of batches of concrete made of identical materials but combined in different orders.

Four batches were tested, the mix being 1 : 2.25 : 2.75, with 7.1 gal. of water per sack of cement, no allowance being made for absorption, which was approximately 1.0 percent. The coarse aggregate was a hard, dense sandstone that breaks with a large proportion of sharply angular fragments and a rough, grainy surface. Fine aggregate was a well rounded river sand having a gradation factor of 3.06 and consisting chiefly of quartz and feldspar. The gradation factor of the combined aggregate was 5.05. All aggregate was in room-dried condition.

MIXING PROCEDURE

Batch A

Cement and water—mixed 1 minute
Add sand —mixed 1 minute
Add stone —mixed 1 minute—Slump, 7¼ in.

Batch B

Cement and sand —mixed 1 minute
Add water —mixed 1 minute
Add stone —mixed 1 minute—Slump, 5⅝ in.

Batch C

Cement and stone—mixed 1 minute
Add water —mixed 1 minute
Add sand —mixed 1 minute—Slump, 6 in.

Batch D

Cement, sand and stone—mixed 2 minutes
Add water —mixed 1 minute—Slump, 3 in.

TESTS

Compressive strength tests were made on 6 x 12-in. cylinders at 14 and 28 days. No significant departures were observed from results previously reported, therefore, results will not be given in detail. At 14 days the ranking was: B, C, D, A. At 28 days it was: B, D, A, C.

Freezing and thawing tests were made on 3 x 4 x 16-in. beams, beginning after 28 days moist-room storage and continuing for 50 cycles. Freezing was at approximately 10 F and thawing was in water at 70 to 80 F. The dynamic modulus of elasticity was determined from time to time and finally after 50 cycles. All beams showed early loss of elasticity followed by slight recovery. No significant change of length or weight could be determined.

A durability factor was computed for each batch (Table A) by expressing the modulus of elasticity at 50 cycles in percentage of that at 28 days for the same beam and dividing the percentage for the frozen beam by that for the control specimen that had been held in moist-room storage.

TABLE A—DURABILITY FACTORS

Batch	Elasticity, percent of 28 day		Durability factor	Rank
	F. and T.	Moist-room		
A	97.0	112.7	0.862	4
B	95.1	108.3	0.877	3
C	94.0	106.8	0.881	2
D	96.0	106.8	0.898	1

These data are too fragmentary to justify any final conclusions, but they certainly indicate a definite trend that promises substantial results from further investigations. It is reasonable to suppose that leaner mixes, being more susceptible to damage by freezing, might show greater divergence of results than were obtained in this series of tests.

It will no doubt be argued by some that modification of the order of mixing is economically impracticable. However, in the case of transit-mixed concrete, present day equipment can be used, without change, to secure any desirable amount of mixing before addition of water. Tandem-drum mixers, with slight modification, can be made to produce the same results by adding the water in the second drum, the first drum being operated "in the dry." The saving of even 2 or 3 percent in required cement would be sufficient to pay for the cost of modifying a central mixing plant to provide for any desirable order of charging.

Here is, indeed, a fruitful field for study.

By J. MacNEIL TURNBULL*

While the results reported in this paper are of much interest, there is no mention of at least two additional alternatives. The first is the method usually employed and the second is that preferred by the writer:

1. Portion of the water (usually about 10 percent)
   Coarse aggregate (sometimes wet)
   Fine aggregate (usually wet)
   Portland cement
   Balance of the water required for the desired water-cement ratio or workability
2. Portion of the water (usually about 10 percent)
   Coarse aggregate (sometimes wet)
   Fine aggregate (usually wet)
   Balance of the water required for the desired water-cement ratio, or up to approximately 85 percent of the total if this is not precisely known
   Portland cement
   Final adjustment of water requirement if the water-cement ratio is not known

Both these procedures assist in keeping the mixer clean, an important point in field mixing. What is the authors' experience in this respect with their recommended order of mixing? It would be of interest if the authors would supply the individual strengths from which each of the reported averages were derived, or the standard deviations, so that the statistical significance of the results could be determined. Was the mixing time recorded from the commencement of the charging of the mixer to the completion of the ejection of the mixed concrete or, as more usual, from the time of the addition of the last component of the concrete to the completion of the ejection of the concrete from the mixer?

AUTHORS' CLOSURE

The following information is presented in answer to Maxon's inquiries. Detailed information on mixing times is tabulated in Table B.

The mixer had a 1 cu ft capacity. The batch figures referred to are *not* stated in pounds but in *parts*. (Originally the figures shown were in grams and proportion was expressed accordingly.)

The various series were made on different days, using different bags of cement, and under varying air temperatures. They are not absolutely comparable with each other as between the three groups shown, but each item *within the group* (*i.e.*, each item shown under Mix No. 1, each item under Mix No. 2, etc.) is strictly comparable with the other sequences of combining materials within that group.

The variations in test repetitions are due to the different bags of cement, and to the fact that the "repetitions of test" were made subsequently, under different ambient conditions.

Referring to Maxon's description of the "usual method of charging ingredients in a tilting mixer," the authors believe (1) that the "usual" order of mixing will not produce the highest strength concrete, for the given

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TABLE B—MIXING TIME

Mix No.	Order of combining materials	Mixing time, minutes	
		Partial	Total
1	(Aa + B + C) + D + E	1 1 1	3
	(B + C + D) + E + Aa	1 1 1	3
	(D + E) + Aa + (B + C)	1 1 1	3
2	(A + Aa + B + C + D) + E	1 2	3
	(B + C + D) + (A + Aa) + E	1 1 1	3
	(B + C + D) + E + (A + Aa)	1 1 1	3
	(D + E) + (B + C) + (A + Aa)	1 1 1	3
3	(A + Aa + B + C + D) + E	1 2	3
	(A + Aa + D) + (B + C) + E	1 1 1	3
	(D + E) + (A + Aa) + (B + C)	1 2	
4	(A + B + C) + E	1 2	3
	(A + B) + E + C	1 1 1	3
	A + E + (B + C)	1 2	3

Note: Mixer was a 1 cu ft laboratory mixer (tilting type) operating at 30 rpm.

materials and cement-water ratio; and (2) the order described probably arose out of a desire to avoid mortar sticking to the mixer (a general trouble with tilting- or revolving-drum mixers). Paddle mixers are preferable, to produce the best concrete readily.

Munger says, "When the water is first in contact with the aggregate, a film of water may be formed that prevents the development of a complete bond."

In October, 1943, the authors made some experiments to study the ability of different aggregates to retain water. The following materials were used: ½-in. screenings (crushed basalt); ⅜-in. screenings (crushed basalt); coarse sand; and fine, white sand. The sieve analysis is given in Table C.

The ½-in. and ⅜-in. screenings consisted of broken basalt; the sand was washed quartz sand with practically no argillaceus matter adhering. The aggregate and sand were tested in the state of perfect dryness. They were submerged separately in water for 1 hour. Then the water-soaked specimens were placed separately on horizontal No. 30 sieves and remained there until no more free water drained out. The water content of the specimens was

TABLE C—SIEVE ANALYSIS

Retained on	½-in. screenings, percent	⅜-in. screenings, percent	Coarse sand, percent	Fine sand, percent
¾-in.	38.27	0	0	0
½-in.	60.95	0	0	0
⅜-in.	0.18	43.05	1.92	0
¼-in.	0.07	29.24	5.85	0
No. 4	—	0.02	0.19	0
No. 6	0.07	5.92	5.40	0
No. 8	0.05	18.47	19.00	0.36
No. 10	0.06	1.64	10.45	0.03
No. 14	0.04	0.85	19.60	0.60
No. 18	0.02	0.10	15.42	—
No. 30	0.02	0.05	9.02	7.97
No. 36	0.02	0.04	4.85	0.90
No. 50	0.01	0.05	6.25	53.90
No. 70	0.02	0.05	1.05	21.88
No. 100	0.09	0.04	0.32	12.92
No. 180	—	0.06	0.10	
Passed No. 100	0.73	0.42	0.48	1.44

TABLE D—WATER CONTENT

Type of material	Water content, percentage of wet weight
½-in. screenings	1.8
⅜-in. screenings	6.6
Coarse sand	17.3
Fine sand	21.4

then determined (Table D).

Thus, 100 parts by weight of ½-in. dry screenings retained 1.81 parts by weight of water: 100 parts by weight of ⅜-in dry screenings retained 7.06 parts of water; 100 parts by weight of dry coarse sand retained 20.91 parts of water; and 100 parts by weight of dry fine sand retained 27.22 parts of water. From this, it can be concluded that the power of the aggregate or sand to retain a cement-water slurry will follow a similar curve to that regarding the water-retaining power. Thus, when fine sand, or sand in general, is mixed first with cement, a rather good bond between the dry cement and the dry sand will be formed due to the intimate contact of the cement with the surface of the sand—as suggested by Munger.

When water is added to this intimate cement-sand mixture, a cement-water slurry will adhere intimately to the surfaces of the sand particles. Due to the surface tension of the slurry, this intimate bond between the sand and the cement slurry will not be entirely destroyed by the addition of the coarser aggregate.

Thus, the cement will be utilized where it is most needed—to cover the great surface area of the fine sand particles. This mortar will envelop the coarser aggregate particle with sufficient bond to bring about a good evolution of strength.

If, on the other hand, a premixed cement-water slurry is mixed with the sand and (or) aggregate, its surface tension will not be so easily overcome by the aggregate or sand; the bond will be poor and the strength evolved inferior. It is likely too that cement will not be well distributed through the mass.

The authors support Munger's suggestion that the film of water formed on prewetted aggregate prevents the development of the best bond.

If these theories are correct, it may also be assumed, since aggregate and sand rarely occur in the dry state in the field, that premixing of cement and sand and water is the natural way to upset the bad effects which damp aggregate or sand may otherwise have on the development of strength.

Some years ago, the authors made tests to determine the effect of various water contents in coarse and fine aggregates. It was found that saturated

aggregates produce concrete of substantially lower strength (when the over-all water ratio is kept constant). This is of importance, since some engineers even prescribe a practice of inundation and draining before use. This will lower the strength of the concrete.

Both of the mixing sequences described by Turnbull are in the authors' opinion undesirable.

No. 1 tends to give considerable water film around each particle of coarse aggregate and hence tends to cause lower concrete strength.

No. 2 is, in the authors' judgment, still worse. Not only does it saturate aggregates and surround the particles with water film, but the cement added to such a wetted agglomeration of aggregates will be badly distributed through the mass.

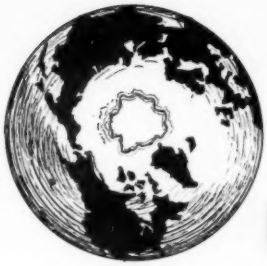
TABLE E—STRENGTH, INDIVIDUAL TESTS

Mix	Comp. strength, psi			Ave.
No. 1*	4334	4390	4284	4336
	4679	4336	5142	4719
	4045	3816	3560	3807
No. 2*	1887	2239	2093	2073
	2090	2043	2347	2160
	2239	2463	2372	2358
	1695	1787	1837	1773
No. 3*	2855	2371	2389	2538
	2669	3079	3109	2952
	3411	3327	3569	3435
	1903	2578	2498	2326
	2935	2552	2921	2802
	3728	3807	3890	3808
	2062	2060	1917	2013
	Tensile stength, psi			Ave.
No. 4†	557	467	486	503
No. 5†	513	531	525	523

*See Table 2.
†See Table 3.

Experience with mixers has shown that (1) tilting or rotating drum mixers are hard to clean and, especially when a low water ratio concrete is used, excessive sticking of mortar to the mixer occurs. (2) This causes the mixing sequence to be fixed to suit the mixer and not the concrete quality. (3) The stationary mixer with paddles or ploughs to stir the mass is easier to keep clean and enables any mixing sequence.

The schedule of individual test figures for the average values in Table 2 are given in Table E and the mixing times are given in Table B.



Letters from Readers*

BY WAY OF SYNOPSIS

J. Fruchtbaum replies to an inquiry about hexagonal grain silos.

Hunter W. Hanly recommends an ACI paper to architects.

Alberto S. C. Fava explains the Argentine term for prestressed concrete.

Paul Rogers presents a simplified analysis for the solution of maximum bending moments.

R. G. Pierides seeks information on trass.

George E. Large, John W. Graham, Jr. and L. C. Urquhart continue the discussion about teaching methods for reinforced concrete design.

Construction of Hexagonal Bins (LR 46-28)

A reader seeks information on hexagonal bins.

My company's malting plant has many concrete silos for the storage of barley and malt. Quite a few new silos are to be built soon. All of the present silos are round with web connections joining silos so that the space between silos can also be used for storage.

Some trouble has been experienced with cracking of the concrete and this has been attributed to improper reinforcing for the loads imposed when the silos are empty but the space between loaded.

It has been concluded that in a comparison between silos of the type we have (but designed to overcome cracking) and a new design consisting of a hive of hexagonal bins, the hexagonal bins, in our case at least, would be the cheaper.

*A part of copyrighted Journal of the American Concrete Institute, V. 21, No. 2, Oct. 1949, *Proceedings*, V. 46. Separate prints are available at 35 cents each. Address 7400 Second Boulevard, Detroit 2, Mich.

We know of many cases where square or rectangular bins have been constructed but never have we heard of hexagonal bins being used. We would like information about such structures, or the feasibility of building them.

J. FRUCHTBAUM, Consulting Engineer, Buffalo, N. Y., gives a partial answer.

It is difficult to say what caused the cracks in the bins mentioned. I have looked over several installations of round bins with web connections and found them all in perfect condition.

Cracking of the concrete might have been caused by any of the following reasons:

1. Uneven settlement of the foundations due to unbalanced loading.
2. The deficiency of vertical steel in the bins. This might be due to the fact that contractors do not like to put in any vertical steel in addition to the jack rods. Since the jack rods are not spliced, only a portion of them can be considered to resist shrinkage.
3. Poor spacing or lap of horizontal bars due to difficulties of placing steel uniformly with sliding forms. We, by the way, always break joints on the horizontal bars.
4. Wherever the webs are long; that is, the space between the circular bins is large, special conditions are set up which occasionally are not taken care of in the design.

One firm has given considerable thought to hexagonal bins, but has not as yet built any of them, although there is no question of their economy as far as the ratio of wall surface to storage capacity is concerned. In a series of hexagonal bins that were built in the Southwest, parts of the outside walls have collapsed, but it was not a design failure. It was a construction failure caused by the omission of reinforcing steel in the particular area.

We have designed a good many rectangular and square bins, but have never had occasion to design any hexagonal ones. On sliding form jobs, it is relatively complicated to place the steel to take care of stresses in rectangular and hexagonal bins as compared with circular bins (no bending).

From the design point of view, there should be no difficulties incurred if bending moments are provided for in the installation. In ordinary circular walls the design is made to take care of tension and compression only. Where flat walls are encountered, bending must be provided for.

Our feeling here is that while the hexagonal bin has less square feet of wall surface per cubic foot of storage capacity, nevertheless, the extra cost of reinforcing steel, and placing of it, and the extra cost of jack-rods and sliding forms due to the corner details, more than eat up the theoretical economy.

Hormigon Elastico—Elastic Concrete (LR 46-29)

ALBERTO S. C. FAVA, Chief of Concrete Division, Laboratorio de Ensayo de Materiales e Investigaciones Technologicas of the Province of Buenos Aires, LaPlata, Argentina, comments on a new term for prestressed concrete used in Argentina, in a letter to C. E. Wuerpel.

The expression *hormigón elástico* as applied to prestressed reinforced concrete, was proposed by the Yugoslavian engineer Zorislav Franjetic, who is at present in Buenos Aires where he is building a plant for the production of precast prestressed reinforced concrete members of structures, and which will operate according to the "Zofra" method.

As a matter of clarification, I will quote some information extracted from the journal *Hormigón Elástico* (Nov. 1948, pp. 9-10). It is a commentary by Garcia Balado (Instituto del Cemento Portland Argentino).

"An element is thus obtained in which, according to tests, the instantaneous deflections show an almost constant modulus of elasticity. If the loads are eliminated, the deflections rapidly and almost completely disappear. Even after cracks are produced in the concrete, and provided that the yield point of steel has not been surpassed, if the loads are eliminated, the cracks close, and the member returns to its original elastic condition. Due to this behavior Franjetic prefers to call it *hormigon elastico* (elastic concrete)."

An editorial note from *Hormigón Elástico*, Jan. 1949, p. 3, is also quoted.

"The elastic concrete is a new type of reinforced concrete obtained by using portland cement concrete of the current type and prestressed steel wires of high strength. It is a new material which has specific characteristics and, unlike common reinforced concrete, is highly resistant not only to compressive stresses, but also to tensile stresses. Moreover, it can be bent like steel. Due to this elastic property, the new homogeneous material, being very different from common reinforced concrete (which is hard and fragile), ought to be called *hormigon elastico* (elastic concrete)."

The terminology used for such construction in various countries includes German, *vorgespannter*; Spanish, *hormigón pretensado*; English, prestressed concrete; Swedish, *strangbeton* and French, *beton precontraint*.

Systems of construction used in various parts of the world include France, Freyssinet; Germany, Hoyer; Belgium, Magnel; United States, Schorer and Yugoslavia, Zofra.

The terms "prestressed," *pretensado*, etc., indicate the new procedure to which the reinforcement is subject, that is, they refer to the constructive process. On the other hand the term *hormigón elástico* indicates the characteristic of this material. If we consider that for each material, the characteristics are more important than the method of production, it seems more justified and adequate to use the term *hormigón elástico* (elastic concrete) than *horimigón pretensado* (prestressed concrete).

Simplified Analysis for Live Loads (LR 46-30)

PAUL ROGERS, Structural Engineer, Chicago, Ill., presents a simplified analysis for the solution of maximum bending moments on continuous beams and frames.

A simplified analysis is presented here for the solution of maximum bending moments on continuous beams and frames due to the influence of uniformly distributed live loads. This problem arises with warehouses, public buildings, etc., where alternate spans may be loaded, and where the spans are not nearly equal, thus eliminating the use of moment coefficients.

No special credit is claimed by the writer. The analysis is still based on moment distribution. It is also possible that many practicing engineers have arrived at similar or identical short-cuts. The writer was not able, however, to find such a solution in any printed publication.

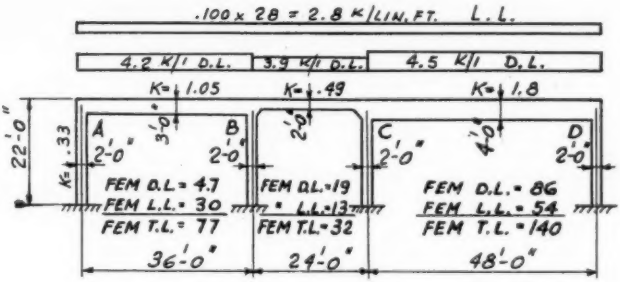
The maximum positive bending moments of a continuous beam or frame are obtained by loading the alternate spans with the live load (L.L.). The maximum negative moments are obtained by loading adjacent spans. In addition, one has the case of all spans loaded with the dead load (D.L.). Thus even for a structure of three spans, several complete analyses are required and the results combined to furnish the maximum moments and shears.

The writer's solution is based on one major distribution only, involving the D.L. and some alternately loaded L.L., possibly in their most unfavorable positions. Moment distribution is carried out and the results recorded.

To obtain the negative moments due to other loadings, one merely has to add, (or deduct) the corresponding fixed end moments (FEM), distribute them, and add them algebraically to the already obtained negative moments. Each span, or a combination of them can be treated separately, until all unfavorable combinations have been applied.

The advantages of this system are two-fold. These additional live load fixed end moments (FEM L.L.) are comparatively small and they converge very rapidly. Secondly, all the operations are continuous and each additional L.L. distribution is automatically registered. Consequently, at the end of the analysis, one can readily draw the corresponding moment and shear diagrams.

As an example, a complete analysis is presented of a three span rigid frame, based (with slight variations) on an actual design of a public building (Fig. 1 and 2). The roof deck is reserved to spectators, who may conglomerate at any point. One hundred lb per sq ft live load is being applied. Spans and other physical dimensions depend entirely on architectural considerations. The total depth between the suspended



MOMENT DISTRIBUTION

JOINT "A"		JOINT "B"			JOINT "C"			JOINT "D"		
24%	76%	56%	18%	26%	19%	12%	69%	85%	15%	
	+77	-77		+19	-19		+140	-140		DEAD LOAD FEM ON ALL THE SPANS; LIVE LOAD FEM ON SPANS "A-B" AND "C-D".
-19	-58	-29	+15	+23	+11	-16	-91	-45	+28	
-7	+24	+49	+4	-12	-25	-9	+78	+157	+4	
-1	+6	+11	+2	-8	-15	-2	-54	-27	+1	
	-23	-11		+5	+3		+12	+23		
	+3	+6		+3	+1		-11	-5		
	-2	-1		-1	-3		+2	+4		
		+1		+1	-1		-1			
-27	+27	-51	+21	+30	-48	-27	+75	-33	+33	DEDUCT LIVE LOAD FEM ON SPAN "A-B" & ADD ON "B-C".
	-30	+30		+13	-13					
+7	+23	+11	-10	-14	-7	+2	+14	+7	-1	
+4	-15	-30	-1	+2	+4		-3	-6		
	+11	+6		-2	-1		+3			
		-5			+1					
-16	+16	-39	+10	+29	-64	-25	+89	-32	+32	DEDUCT LIVE LOAD FEM ON SPAN "C-D".
							-54	+54		
	-2	-4	-1	+7	+15	+9	-23	-46	-8	
	+2	+1		-2	-1	+2	+53	+26	-4	
		-1		+1	+2		-11	-22	-1	
				-1			+8	+4		
								-3		
-16	+16	-43	+9	+34	-48	-14	+62	-19	+19	ADD LIVE LOAD FEM ON SPAN "A-B".
	+30	-30								
-7	-23	-11	+7	+11	+5	-1	-3	+1		
-3	+11	+23	+1	+1	-1			-1		
	-8	-4								
		+2								
-26	+26	-63	+17	+46	-44	-15	+59	-19	+19	

Fig. 1—Dimensions, stiffness factors, fixed end moments and moment distribution (All moments are in ft lb/10,000)

ceiling and the top of beams is 48 in., which is fully used for the 48-ft span. The 24-ft span houses air conditioning ducts, permitting a depth of not more than 24 in., and the 36-ft span includes many pipes for utilities up to 12 in. in diameter. The construction is of 12-in. deep concrete joists plus a 3-in. concrete slab, the pans being stopped one foot short of the girders, thus providing a tee of 48 in. The frames are 28 ft apart and the columns are considered fixed at the bottom due to the substantial substructure.

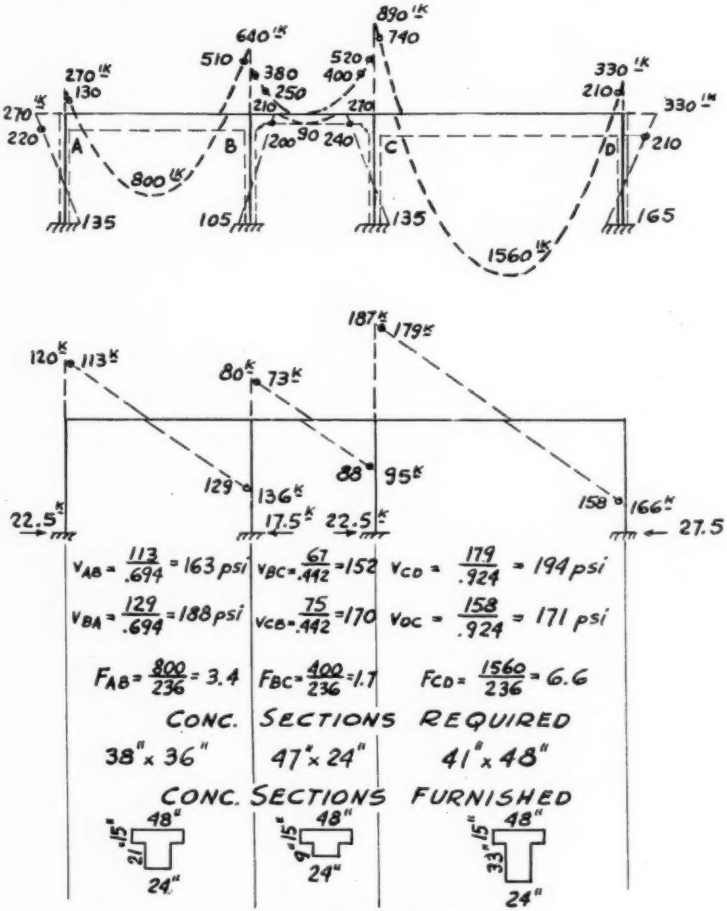


Fig. 2—Moment and shear diagrams

Floor Finishes (LR 46-31)

HUNTER W. HANLY, Hanly and Young, Civil and Structural Engineers, Cincinnati, Ohio, recommends Morgan B. Klock's paper in the June JOURNAL to architects.

The June issue of the JOURNAL published an excellent article by Morgan B. Klock on the subject of "Monolithic and Bonded Floor Finishes." I should like to have a dozen copies of the separate print to distribute among some architect friends who need to know what Mr. Klock says and who may possibly have the time to read the article with enough close attention that they will wind up getting better results from their own specifications.

Turning back the hands of the clock, I am enclosing a photograph (Fig. 1) that was made in 1909 of the operation of applying a finish such as Mr. Klock describes. With only the hand rammer and the hand trowel for use in surfacing this very dry mix instead of present day power surfacers, results were still excellent although the work was back-breaking.

Fig. 1—Good floors were "harder" to get in 1909

Trass Cement (LR 46-32)

R. G. PIERIDES, New York State Dept. of Public Works, Bronx, N. Y., asks for information about trass.

Information is desired on trass, relating to its description, occurrence, identification and the methods used in exploring and developing trass deposits. How is trass used in producing hydraulic cement and what are the test methods and the results?

Teaching Reinforced Concrete Design—What Should We Emphasize? (LR 45-21)*

Prof. GEORGE E. LARGE, Chairman, Dept. of Civil Engineering, Ohio State Univ., Columbus, Ohio, discusses further the question raised in the June JOURNAL.

Prof. Holley's suggestions on what should be emphasized in a basic course in reinforced concrete design have prompted me to make some comments arising out of twenty years experience in teaching the subject.

Since nearly all the existing texts are of the reference type, containing very little of the daily demonstration work, drill work, laboratory problem work, discussion and quiz questions needed to teach undergraduates, each instructor must evolve his own short list of "must" topics, and concentrate upon them in his own way until the students *understand* them reasonably well. This understanding develops principally from experience in attacking a well chosen group of problems, rather than from listening to lectures or reading abstract textbook prose.

During the first three weeks at Ohio State we concentrate daily on the flexure of simply supported and cantilever beams, including rectangular, tee and doubly reinforced, by the transformed section method. The trusty old reinforced concrete formulas, and the $\frac{Mc}{I}$ formula are barred during this period of discipline. Great emphasis is placed upon the importance of distinguishing between (a) investigation and (b) design situations. An examination is conducted at this point.

Next, about three days are spent deriving the flexure formulas, and in applying them in the laboratory to the construction of a useful chart. No other use is ever made of them thereafter, as the students are immediately provided with a set of beam charts.

A minimum of 2½ weeks should be devoted to the important topics of bond, shear, diagonal tension and anchorage, which were not mentioned by Prof. Holley. Every student is first required to work by the time-consuming "unit slice" method, from which the diagonal tension formula, $v = \frac{V}{bjd}$ follows easily. He is induced to discard the homogeneous beam concept of vertical shear across a right section in favor of "diagonal tension at 45° in reinforced concrete" and the terms "unit vertical shear" and "unit horizontal shear" are made taboo. Drills to find the direction and value of the diagonal tension in beams

*See also ACI JOURNAL, June 1949, *Proc.* V. 45, p. 745 and Sept. 1949, *Proc.* V. 45, p. 67.

of irregular section and in odd positions are very educational. A beam employing correctly spaced and anchored bentup bars and stirrups is designed, and complete "design sketches" showing all the construction to scale are required. No design drawings of complete structures are attempted, since the ACI *Manual of Standard Practice for Detailing Reinforced Concrete Structures* gives the student plenty of background for this when and if the need arises.

From three days to a week may next be profitably spent testing a full sized reinforced concrete beam with stirrups, and in the preparation of a formal report. The student's observation of the development and progress of the tensile cracks as the test proceeds fixes the classroom work in his mind as nothing else will.

At least 2½ weeks are needed for the subject of columns if the student is to understand direct stress plus bending situations. We must continue to teach the elastic method when bending is involved, with only a limited recognition of plasticity. Since a small amount of added bending cannot make a fundamental difference in the internal action of columns, attention must be called to this present inconsistency in our theory. Considerable time is spent in teaching logical column *design* methods, as distinguished from investigations, as no known texts take up these important techniques adequately.

During the last two weeks, the design of a slab, beam and girder floor is taken up, as it demands the application of all that has been learned earlier, and more too. Some practical continuity method, such as moment distribution, is recalled, and applied to the determination of the dead load and live load bending moments in the continuous slab, then later to beams and girders, and the results compared with the Code coefficients. In the course of slab design the topic of special anchorage is finally introduced. Lastly, one span of a continuous beam is quickly proportioned (designed) for diagonal tension, negative bending moment and positive bending moment using three fundamental expressions, and checked for flexure at the support by the *2n* plastic method of "Building Code Requirements for Reinforced Concrete (ACI 318-47)" Sec. 706(b).

Throughout the laboratory computation work the importance of maintaining a high standard of paper neatness and organization, such as is inculcated in "engineering problems" courses at some institutions, can hardly be overestimated. If the instructor will set the example in his own blackboard lecture and demonstration work, the student will respond accordingly, and later make a good impression during his very first day on the job.

Prof. JOHN W. GRAHAM, JR., Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa., comments on teaching methods also.

Prof. Holley has raised the question: "Teaching Reinforced Concrete Design—What Should We Emphasize?" This question cannot be answered satisfactorily without considering the general educational plan of the institution concerned. One philosophy predominant in engineering education today might be paraphrased as "to *train* students to *be* professional practitioneers *at* graduation so as to be of maximum initial value to an employer." A quite different philosophy, which is being given considerable emphasis by some schools is "to *educate* students so that they will *become* professional men of ever-increasing value in their profession and in society as they grow in wisdom and stature *after* graduation." The first philosophy is concerned with training for technical proficiency—the second with learning to think. There are merits in both, and most schools find themselves someplace between the two objectives. The purpose of this discussion is not to argue with any philosophy, but rather to point out that different ones do exist, and thus that no two courses in reinforced concrete design can be expected to give the same emphasis.

Carnegie Tech's course in reinforced concrete is consistent with the Carnegie Plan of Professional Education in Engineering and Science which has been clearly defined.* The course is not static—both content and method of presentation are purposely kept in a state of flux to encourage the development of a better course each time it is taught. However, certain basic philosophies for the course are firmly established:

1. The student's interest must be aroused and maintained. Without interest, all efforts to instill disciplines will be to no avail.
2. The course content must be concerned only with fundamentals. Particular care must be taken to distinguish between (a) the development and application of theory based on stated assumptions (b) the application of governing specifications and (c) the application of engineering judgment.
3. The student learns by doing—not by being told. One mistake made in an effort to learn for himself is worth 100 demonstrations of the "this is how you do it" variety.
4. The quantity of subject matter covered is far less important than the quality—than insuring that, that which is done is done well. For each problem considered, the student should be encouraged to state his problem accurately, plan the treatment deliberately, execute the plan systematically, check the work, and review and reflect upon what has been done.
5. The student's ability to work as a member of a "team" should be promoted and developed.
6. The student must be stimulated to "further study," both while he is taking the course and after he has completed it.

*See any of the current bulletins of the Carnegie Institute of Technology.

Accordingly, the answer to Prof. Holley's question depends upon the school—upon the teacher, student, and program, and the way in which they work together.

L. C. URQUHART, Chief, Engineering Division, Honolulu Office, Corps of Engineers, U. S. Army (formerly Prof. of Structural Engineering, Cornell Univ.), believes tables and diagrams are important in teaching reinforced concrete design.

Prof. Holley's letter in the June JOURNAL is interesting and should bring forth some valuable discussion. When one considers that courses in reinforced concrete are comparatively young when compared with courses dealing with stress analysis and design of steel and timber structures it appears very probable that the basic pattern for such courses has not reached the most desirable development.

It is the writer's opinion that the introductory course should not cover too much ground, and the drill in the design of the elementary members should be thorough with considerable attention given to the practical details of design as well as to the theory. It may be desirable to make use of the transformed section in introducing the student to beam design, but since the linear theory should offer no difficulty it does not seem necessary to carry this beyond the rectangular beam. The equations of the linear theory and their derivations should be thoroughly stressed and practice in design and review by their use is desirable. However, once this has been accomplished, it is the opinion of the writer that tables and diagrams should be explained and made use of thereafter. If the student is compelled to use equations in the drill for T-beams and beams reinforced for compression the solution of problems becomes more of a course in arithmetic than reinforced concrete design and the theory of the latter is liable to be lost in the shuffle.

Following the study and practice in the design of the various types of beams, slabs, columns and simple footings, it is desirable to tie all of these elements together in the design of the floors and frame of a small reinforced concrete building. This may be simplified if desired by considering end spans freely supported, but it is believed that instruction in the distribution of unbalanced moments could easily be given, even where the student has not had a course in indeterminate structures. All introductory courses should follow or be given concurrently with a laboratory course to familiarize the student with the materials involved and the means required to hold the reinforcement in its proper position. Where reinforced concrete construction is in progress a visit to such a project is a desirable part of such a course.

Whether further study of reinforced concrete design is given at the undergraduate or graduate level depends upon the time available in the undergraduate curriculum. Familiarizing the student with the various types of structures to which reinforced concrete is adapted might well cover several courses. In any of these, particular attention should be given to code requirements; aids in design such as appear in the *Reinforced Concrete Design Handbook* should be brought into use.

To broaden the student's conception of reinforced concrete a course in research such as that suggested by Prof. Holley would certainly be desirable. In most instances this should be at the graduate level for students whose primary interest is reinforced concrete. Such a course will stimulate thinking and should result in continual study on the student's part for years after graduation.

Current Reviews*

of Significant Contributions in Foreign and Domestic Publications

The lifting of clay and concrete floor tiles

Digest No. 7, Building Research Station, Watford, England

Failure of bond between concrete subfloors and tile surfaces is discussed. A layer of sand under the mortar holding the tiles or separation of the mortar from the subfloor by a paper or felt layer are recommended to prevent arching or ridging of the tiles due to differential expansion or contraction.

Steam curing of concrete

R. W. Nurse, *Magazine of Concrete Research* (London), No. 2, June 1949, pp. 79-88 — Author's Summary

The various methods of steam curing are described briefly and preliminary laboratory data on the effect of low pressure curing are given. An approximate method for assessing the effect of a stated cycle of operations is described. The effects of time and temperature, type of aggregate, type of cement and size of specimen are discussed.

A plastic theory of design for ordinary reinforced and prestressed concrete including moment re-distribution in continuous members

A. L. L. Baker, *Magazine of Concrete Research* (London), No. 2, June 1949, pp. 57-66 — Author's Summary

A general expression is derived for the ultimate strength in bending of ordinary reinforced concrete and two types of prestressed concrete beams, taking into account plasticity. A method of calculating elasto-plastic deformations is developed and applied to the problem of redistributing bending moments in continuous members and frames.

Suggested unit course in form construction

Delmar Publishers, Inc., Albany, N. Y. $1.65 — Reviewed by E. B. Oberly

Some of the methods of form construction described, while not altogether wrong, have not been used for a good many years as we have learned new and better ways. Wire is seldom if ever used today to tie forms as it will stretch and even it if does hold would have to be cut back to permit patching of the hole. The material and placement of braces, studs and column clamps illustrated, in some cases, leave something to be desired. In many instances form pressures are not adequately provided for in the form details shown.

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Investigation and laboratory testing of vermiculite deposits, Llano County, Tex.

W. D. McMillan and A. W. Gerhardt, *Report of Investigations* 4486, U. S. Bureau of Mines, July 1949, 42 pp.

The general geology of the region and the location and extent of vermiculite deposits indicated by test pits and borings are discussed and illustrated by maps and charts. Data are given from tests on size grading and vermiculite content of the raw material and from laboratory studies of optimum exfoliation temperatures.

Assembly hall at Filton for Brabazon aircraft

Concrete and Constructional Engineering, V. 44, No. 6, June 1949, pp. 179-186

Reviewed by Glenn Murphy

The concrete work described includes the foundations, floors, and galleries for the structure, the framework of which is steel. The foundations are designed to prevent overturning of the structure with a 105-mph wind. The floor consists of a 9-in. slab cast over a 6-in. slab, and is designed for a 30-ton load on each of the four wheels of the main landing gear of the Brabazon. A description of structural details is included.

Full-scale research on the design of concrete pavements and their foundations for heavy wheel-loads

Robert R. Philippe, Ohio State Engineering Experiment Station *Bulletin* No. 136, 1949, pp. 114-134

A progress report on the investigations of rigid pavements by the Corps of Engineers, Department of the Army, beginning in 1941. The various phases of rigid pavement design discussed are thickness, base course, reinforcements, joints and joint transfer devices, and thermal stresses. Data are presented showing the results of loading tests on several types of pavements, base courses, and subgrades. Tentative design requirements are then stated in relation to the factors enumerated above.

50 Years of the German Concrete Association, 1898-1948 (50 Jahre Deutscher Beton-Verein, 1898-1948)

Deutscher Beton-Verein (Wiesbaden), 1949, 195 pp. Reviewed by Rudolph Fischl

This book deals with the history and organization of the German Concrete Association, its activities, standards, regulation of arbitration and fees. Further, it contains a list of the officers, honorary and ordinary members and finally a complete bibliography of the lectures and reports given at the conventions of the past 50 years, classified in 25 special branches, and covering 100 pages.

Development of the idea of prestressing (Expose d'ensemble de l'idee de precontrainte)

M. E. Freyssinet, *Annales de L'Institute Technique du Batiment et des Travaux Publics*, New Series No. 77, June 1949, Beton Precontraint No. 13, 52 pp.

The means of prestressing are discussed and loss of prestress through creep in the prestressing steel shown to be negligible. The various methods of anchorage and tensioning of prestressing cables are compared and the combination of the double-acting hydraulic jack with the reinforced concrete anchorage cone found to be the most flexible and efficient. Methods of prestressing pipes and means of applying steelless prestress to structures by built-in jacks are mentioned.

The limitless field of application of prestressed concrete is then illustrated by examples of accomplishments to date. These include factories producing standard elements for building construction, railway sleepers and pipes. Hydraulic presses, tunnels, galleries, reservoirs, bridges, piles, caissons, barges, floating docks, pylons, dams and airfield runways are some of the many existing prestressed concrete structures referred to.

Laboratory method for determining the air content of fresh concrete

J. D. McIntosh and A. G. Preston, *Magazine of Concrete Research* (London), No. 2, June 1949, pp. 93-97 — Author's Summary

A method for determining the amount of air entrained in fresh concrete, based on the variation of air volume with pressure, is described and illustrated. It is intended for laboratory use, and from the point of view of convenience in making the test is particularly suitable for this purpose. One form of apparatus can be readily assembled from standard chemical equipment and other common materials. The reproducibility and accuracy of results appear to be good.

Apparatus and methods employed in the X-ray examination of cement compounds at Birkbeck College Research Laboratories

J. W. Jeffery, *Magazine of Concrete Research* (London), No. 2, June 1949, pp. 99-106 — Author's Summary

The scope of the work being undertaken in the Cement Section of Birkbeck College Research Laboratories is outlined. A brief account of the phenomena of X-ray reflection from crystals is followed by a description of: (a) X-ray tubes, high tension gear and general layout of the laboratory; (b) powder cameras and accessories, and powder photographs; (c) single crystal cameras and photographs; (d) a special camera for long range work; (e) photographs taken of hydration products using a mica cell and (f) auxiliary apparatus.

Concrete-lined irrigation channel (Canal con revestimiento de hormigon)

Cemento Portland (Buenos Aires), V. IV, No. 18 and 19, Feb. and May 1949, pp. 10-11 — Reviewed by Francisco J. Cordova

This report deals with the construction of a concrete-lined irrigation channel in the Province of Mendoza, Argentina, which when completed, will have a total length of 50 km. To prevent excessive underground seepage this channel is lined with plain concrete from 0.15 to 0.30 m thick. This structure, as it crosses the town of Lujan de Cuyo, becomes a circular conduit. The open channel is lined with concrete containing 250 kg of cement per cu m, while the concrete of the circular conduit section contains 300 kg of cement per cu m. To insure efficient curing, a membrane was sprayed on the exterior surface of the concrete lining.

A cross section of the channel and photographs are shown.

Statistics of tests on mortars and concretes (Essais statistiques sur mortiers et betons)

Marcel Prot, *Annales de L'Institute Technique Du Batiment et des Travaux Publics* New Series, No. 81, July-Aug. 1949 — Author's Summary

The mechanical properties of any material can only be said to be well known after sufficient tests have been made to obtain a fairly precise average value on the one hand and a dispersion index on the other. The question arises as to how many tests are to be carried out in practice. The tests of which the results are given in this report answer the question as fully as possible, *i. e.*, they indicate what degree of precision can be reached in given test conditions when the number of tests is varied.

These tests were carried out using specimens of different sizes, so that attention is drawn to the effect of the size of test pieces on the results obtained—a fact which is not well known; the dispersion index, in particular, appears to be a somewhat variable function of the similarity of test pieces.

The practical conclusion of these experiments is that, if the traditional safety factors are raised to no purpose for large-sized pieces, they may on the other hand be inadequate for pieces of small thickness.

Bulletins on standards (Buletinul de Standardizare 1-5)

Rumanian Standard Commission, V. 1, No. 1-5, 1949, pp. 1-94 Reviewed by PAUL ROGERS

These are the first few standards approved by the newly formed Rumanian Standard Commission. The standards apply for "Sizes and Scales of Engineering Drawings," "Square Bars," "Lime," "Sugar," Resinous Timber," etc. It is of special interest that it is openly admitted that most of the new standards will be coordinated with the Standards of the Soviet Union. In the preface, by a Rumanian Minister, severe attack is leveled at the foreign interests who formerly owned and operated almost all Rumanian industries, and who allegedly prevented the application of national standards. In spite of this attack, request is made for foreign standard publications, and indeed some of the new standards are based partly on Russian and partly on German standards.

Precast concrete construction in chalk cuttings

Concrete and Constructional Engineering, V. 44, No. 6, June 1949, pp. 187-191
Reviewed by GLENN MURPHY

The Southern Region of British Railways has used precast concrete blocks to protect the slope of two cuts, one near West Sutton, the other near Merstham. The construction near West Sutton involves grooved inclined columns at 10-ft intervals, extending up the slope. The panels, which are 9 ft x 3 ft x 4 in. thick, are designed to be slid into place in the grooves of the columns, forming a complete cover.

The wall near Merstham is primarily for debris retention and consists of a series of transverse walls faced with precast slabs and topped with four courses of cellular concrete blocks, open on the side away from the tracks. The blocks are approximately 6 ft long and 2 ft square, with wall thicknesses of 4 in. and 6 in., while the lower wall is 4½ in. thick. All joints in both walls are dry.

Cantilever slab submitted to concentrated load (Punklast pa kon solplatta)

SUNE TORNQVIST, *Betong* (Stockholm), V. 34, No. 2, 1949, pp. 98-102
AUTHOR'S SUMMARY

In this paper, the structural action of a cantilever slab submitted to a concentrated load is determined by means of the differential equation of the slab. This equation is solved by using Levy's expression on the assumption that Poisson's ratio $\nu = 0$. To begin with, the concentrated load is assumed to be applied at the center of the free edge of a slab which is supported along three edges, so that the edge opposite to the load is fixed, while the other two edges are simply supported. Cantilever action is obtained by removing these two edges from each other to such a distance that their effect on the unknown restraining moment at the center of the slab becomes infinitely small. The constant value of the moment which is finally obtained is the cantilever moment of the slab, and is equal to the maximum ordinate of the sine-shaped edge moment curve at the point of application of the concentrated load.

Convention Lectures, 1948 (Hauptversammlung 1948, Vorgraege)

Deutscher Beton-Verein (Wiesbaden), 1949, 177 pp. Reviewed by RUDOLPH FISCHL

This book reprints the following lectures and discussions of the 1948 convention of the German Concrete Association: "New Tasks for the German Committee for Reinforced Concrete" by Bernard Wedler, Berlin; "Suggestions of the D.B.V. for the Work of the German Committee for Reinforced Concrete" by Erich Bornemann, Wiesbaden; "Recent Reinforced Concrete Bridge Construction" by Walter Sigmundt, Stuttgart-Vaihingen; "Shell Ship Building (Schalenschiffbauten)" by Ullrich Finsterwalder, Muenchen; "Gas Concrete, Foam Concrete, Lightweight Lime Concrete" by Otto Graf, Stuttgart; "The Technical Research in Concrete After the Beginning of the War"

by Georg Wästlund, Stockholm; "Specification of Floors, Roofs and Stairs in Precast Reinforced Concrete" by Fritz Leonhardt, Stuttgart; and "Co-Report to the Foregoing Lecture" by Peter Bonatz, Frankfurt a.M.

An appendix with numerous pictures, which illustrated the lectures, is added.

Prefabricated concrete house (Vivienda de hormigon con elementos prefabricados)

Cemento Portland (Buenos Aires), V. IV, No. 18 and 19, Feb. and May 1949, pp. 7-9 Reviewed by FRANCISCO J. CORDOVA

This paper describes an experimental prefabricated concrete house built in the city of Tucumán, Argentina, applying a construction method developed by Savador Froia. This house consists of five different types of prefabricated structural members, namely; columns, beams, roof slabs, exterior wall slabs and interior wall slabs. The columns and beams are made of reinforced concrete. The roof slabs are made of two layers, one of reinforced concrete, and the other of an insulation material. The exterior wall slabs also are made of two layers, one of reinforced concrete, and the other consists of a mixture of gypsum, sawdust or sugar cane trash. The interior wall slabs are entirely of a mixture consisting of gypsum, sawdust or sugar cane trash. The house measurements are 11.30 m x 6.78 m.

Constructional details are described. A plan of the house and photographs showing construction operations are included.

Research on the rational utilization of demolition debris in concretes and mortars for housing construction (Recherches sur l'utilisation rationnelle des debris de demolition dans les betons et les mortiers destines a la construction d'habitations)

M. A. KOBYLINSKI, *Annales De L'Institute Technique du Batiment et des Travaux Publics*, New Series, No. 84, July-Aug. 1949

The author describes the huge piles of ruins which covered Poland, Germany and the devasted areas of the Soviet Union and the task of reconstruction. The first step in solving the problem, *i. e.*, clearance of debris, which takes precedence over rebuilding on another site, raised three further problems: sorting the debris, preparing it for re-use, and removing waste material. The second problem is dealt with in greatest detail.

The author concludes that unsorted debris cannot be used without further preparation for making concrete but that systematic sorting—described in the report—provides a suitable material for making porous or compact concrete, as well as mortar and renderings. Using a larger porportion of cement it is possible to make reinforced concrete, but it is advisable to avoid its use in places exposed to water.

Mirrored model gives slab moments

GERALD BOWEN, *Engineering News-Record*, V. 143, No. 1, July 7, 1949, pp. 70-72

A new stress analyzer, based on optics rather than mechanics, was developed in conjunction with the solution of design problems in a large housing project. A model of the floor slab with a highly reflective plane surface reflects the image of a grid or accurately spaced, uniform network of lines. The angular distortion of the surface of the model under air pressure loading is then recorded photographically. From this negative the distortions of the grid are measured and plotted.

Adaptations of the measuring mechanism make it possible to record zero bending moment lines, value and type (positive or negative) of the bending moments at all desired points, a complete bending moment diagram and finally, the points of contraflexure of the bending moments.

Plotted data and subsequent calculations are used in determining the actual reinforcement requirements of the slab.

The principle of measuring bending moments by angular distortion of the model surface can be applied to any plane surface that can be bent. It holds equally well for beams as for floor slabs, the difference being in the form of equation used.

A reinforced concrete floating dry dock (Dique flotante de hormigon armado)

Cemento Portland, (Buenos Aires), V. IV, No. 18 and 19, Feb. and May 1949, pp. 2-6

Reviewed by FRANCISCO J. CORDOVA

This article describes the engineering features and construction of a reinforced concrete floating dry dock recently built in a ship yard in Montevideo, Uruguay by the Uruguayan company, Metalúrgica y Diques Flotantes, S. A. The Argentine company, ASTISUR, recently acquired this structure for use in the Port of Buenos Aires, Argentina.

The structure was designed for a potential lift of 6000 tons and will be suitable for totally loaded ships with displacements of 20,000 tons. It is 141.6 m long, 33.0 m wide and 13.9 m high and is 22.8 m wide between wall guards. The pontoons are 124.8 m long and 5.0 m high. The total weight is over 15,000 tons.

Special cement of low heat of hydration and resistant to the sulfates present in sea water was made by Fábrica Uruguaya de Cemento Pórtland. The mixture design specified the following quantities per cu m: cement 446 kg, fine aggregate (dry) 760 kg, coarse aggregate 960 kg, and water 174 l.

The article further describes constructional and design features of the superstructure. Drawings and photographs are shown.

Bond in prestressed concrete (La adherencia en el hormigon precomprimido)

ULF BJUGGREN, *Hormigon Elastico*, (Buenos Aires), V. 2, No. 1, Jan. 1949

Reviewed by FRANCISCO J. CORDOVA

This paper discusses bond characteristics of reinforcement in prestressed concrete (pre-tension prestressed concrete). The theoretical difference between this type of concrete and post-tension prestressed concrete becomes evident during the cracking phase of the concrete, during which pre-tension prestressed concrete will show less deformation, greater shearing strength, and sometimes greater flexural strength due to existing bond between the reinforcement and the concrete.

The author structurally and mathematically analyzes bond and anchorage, contraction and creep, and flexural strength. He further explains the importance of bond in a cracked beam.

The last part of this article is devoted to a discussion of the fabrication of prestressed concrete structures in Sweden. In 1942 the Swedish firm, AB Betongindustri, began producing prestressed concrete structural members, applying the Hoyer system. A description of this firm's method of constructing transmission line posts, bearing piles, thin slabs, beams and floor structures is given. Several photographs, diagrams and graphs are also shown.

Shell type concrete ships (Betongfartyg av skalkon struktion)

ULRICH FINSTERWALDER, *Betong* (Stockholm), V. 34, No. 2, 1949, pp. 57-70 AUTHOR'S SUMMARY

To save steel, concrete ships were built in Germany shortly after the First World War but could not compete with steel ships. This was primarily because the rib structure of concrete ships, which was modeled after steel ships, was not adapted to the peculiar character of concrete as a structural material. It was the adoption of shell type structures that finally made possible the construction of concrete ships which proved able to withstand impact stresses to the same extent as steel ships, while their freight-carrying capacity was only slightly smaller. In addition, these concrete ships

offered some special advantages over steel ships. The ultimate structural design and the streamline form of the new concrete ships built in Germany during the second World War were based on systematic tests. Special advantages were gained by the use of lightweight concrete.

Four different types of concrete ships were developed in Germany, *viz.*, 3770-ton motor tankers and 3650-ton steamships for marine navigation, 1160-ton freight barges for inland navigation, and 337-ton motor cargo ships for coastal trade. Practical experience and the results of tests, which also dealt with the possibility of repairing damaged ships, have proved that the new shell type concrete ships evolved in Germany can certainly be utilized in peace time. This cannot be said of the concrete ships of the old rib structure type built in the United States during the second World War.

Elastic (Pre-stressed) concrete and its advantages in the development of the Five-Year Plan (Hormigon elastico y sus ventajas en la ejecucion del Plan Quinguenal)

Hormigon Elastico (Buenos Aires), V. 2, No. 1, Jan. 1949, pp. 18-19

Reviewed by ALBERTO S. C. FAVA

This article is intended to demonstrate the advantages that elastic concrete would accrue to Argentina if it was used instead of common reinforced concrete. It points out that the Plan of Public Works for 1947-1951 provides for the construction of approximately 10 million sq m (12 million sq yd) of building covered area per year, for houses, hospitals, schools, public buildings, etc. The quantity of materials needed to build one square meter (1.2 sq yd) of building covered area, using current methods and common concrete compared to elastic concrete technique is given below:

	Common concrete	Elastic concrete
Sand	0.20 cu m (7.1 cu ft)	0.040 cu m (1.4 cu ft)
Portland cement	70 kg (154 lb)	16 kg (35 lb)
Steel	20 kg (44 lb)	2 kg (4.4 lb)
Wood	0.050 cu m (1.77 cu ft)	0
Hours of work	5	1

In addition, the cost of scaffoldings and forms would be eliminated. According to the author, and taking into account actual costs, the use of elastic concrete would effect savings of about 700 million pesos per year in buildings alone.

The paper also explains the advantages of elastic concrete railway sleepers if used in lieu of those in common use, made of "quebracho" wood. Considering that Argentina needs 2½ million sleepers per year, and that 5 or 6 hours of work are required to produce one quebracho sleeper, while one made of elastic concrete only requires ½ hour, 5 million working hours would be saved every year. As far as strength and durability are concerned, the latter surpasses the former and even those made of steel.

In short, elastic concrete would offer the following advantages: it is produced in plants, scaffolding and forms are eliminated in the field, and materials as well as transportation and labor are saved. Furthermore, the work can be done more rapidly.

Appraisal of membrane method of curing concrete pavements

C. C. RHODES and J. R. EVANS, *Bulletin* 108, Michigan Engineering Experiment Station, East Lansing, 70 pp. $1.00

Results of laboratory and field studies of white and clear curing membranes compared to conventional wet curing methods are reported in detail. Emphasis in the laboratory work was on the effect of change in moisture condition at several different temperature levels on volume changes and the rate of development of strength and elastic modulus and a direct comparison of the membrane method with a standard wet method of curing with respect to warping, or curling, of concrete slabs under radiant

heat. Field studies were concerned with the practicability of the use of white-pigmented curing compounds on pavements and the gathering and interpretation of data on the condition of recently constructed concrete pavements cured with clear membrane compounds.

The authors summarize the results of the investigation as follows:

1. The original water content of a plastic concrete paving mix is approximately double the amount required for hydration of the cement compounds. Water in excess of minimum hydration requirements must be available, however, as a medium for the continued actions of hydrolysis and hydration during the curing period.

2. The results of this investigation strongly indicate that retention of about 80 percent of the original net mixing water at the end of a 7-day curing period is sufficient for continued hydration and development of adequate strengths during the period.

3. In most regions of this country the particular method of artificial curing initially employed does not significantly affect the ultimate strength or behavior of pavement concrete at advanced ages.

4. The method of curing does affect the physical properties and structural stability of pavement concrete at early ages, however, through its influence on temperature and moisture gradients within the slab. On hot summer days the effects of temperature during the early hardening period are critical, but the occurrence of temperature cracking in a pavement of given design depends not only on the rate and extent of temperature change but also on the character of the subgrade, the physical and chemical properties of cement and aggregates, and the proportioning, mixing, placing and finishing of the concrete.

5. There is considerable evidence to show that temperature cracking is apt to occur more frequently in sections of pavement poured in the morning than in the afternoon on hot summer days. When using membrane curing compounds such cracking can be appreciably reduced by: (1) the use of white-pigmented curing compounds; (2) initial 24-hour curing with wet burlap, followed by saturation with water and application of membrane; (3) the use of dry, protective coverings of other types in conjunction with membrane compounds, including shading; or (4) by shifting construction operations to a later period of the day.

6. Pavements poured in hot weather exhibit concave upward warping only, the degree of which is determined largely by the magnitude of the temperature gradient existing when the concrete sets and hardens, and the time of application of curing materials.

7. Although curing with wet coverings under ideal circumstances still provides the most favorable conditions within the concrete during the setting and early hardening period, it is definitely recognized that ideal conditions are extremely difficult to realize in practice and seldom obtain on a pavement construction project. For this reason, more uniformly satisfactory results are to be expected from the use of membrane curing compounds than from those methods which demand constant attention and supervision during the entire curing period.

8. For construction during the fall or early winter in temperate climates membrane curing has the advantages of preserving warmth in the slab through restriction of evaporation, and of creating a condition of minimum saturation at the threshold of the freezing season.

9. There was no significant difference in surface hardness or wear resistance of concrete beams cured with wet burlap and white membrane. Beams cured with clear membrane exhibited somewhat lower resistance than the others.

10. Available data show that the unit cost of membrane curing before the war was about half that of wet curing methods.